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Sustainable Development by Dematerialization in Production and Consumption— Strategy for the new Environmental Policy in Poland

Results of the Research Project: "ECOPOL: Ecological Economic Policy — Strategy for Poland in the 21st Century" conducted in 1998–1999 by the Institute for Sustainable Development, Warsaw (Poland) and the Wuppertal Institute for Climate, Environment and Energy, Wuppertal (Germany)

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Introduction

This report presents the results of the research project "ECOPOL: Ecological Economic Policy – Strategy for Poland in the 21st Century", supported by the Polish-German Co-operation Fund in Warsaw. The main partners are: the Institute for Sustainable Development in Warsaw and the Institute for Climate, Environment and Energy in Wuppertal, Germany (Wuppertal Institut für Klima, Umwelt, Energie GmbH).

The Institute for Sustainable Development in Warsaw (Instytut na Rzecz Ekorozwoju — InE) is a non-governmental organization with foundation status, established in 1999 to promote, develop and implement in practice the principles and methods of sustainable development. The mission of InE is to work for faster implementation of the principles of sustainable development through building bridges between the environment, the economy and the public in the special circumstances of the period of political and economic transition in Poland and its accession to the European Union. InE achieves these objectives by initiating and contributing to the establishment of sustainable development institutions with respect for the needs for the future generations.

The Wuppertal Institute for Climate, Environment and Energy (Wuppertal Institut für Klima, Umwelt, Energie GmbH — WI) in Wuppertal, Germany (referred to as the Wuppertal Institute below), located in the Scientific Research Centre of North Rhine-Westphalia, is one of the largest institutes in Germany; since 1992, it has done systematic work on global environmental challenges and undertaken comprehensive tasks in the field of studies and analyses of environment-related structural changes. The Wuppertal Institute mediates between science, economy and politics. The President of the Wuppertal Institute is Prof. Dr. Ernst Ulrich von Weizsäcker, a world-known scientist, a member of the Club of Rome.

The ECOPOL Project was coordinated at the Division of Material Flows and Structural Change (*Abteilung für Stoffströme und Strukturwandel*) of the Wuppertal Institute by Dr. Maria J. Welfens and Dr. Helmut Schütz. The research tasks of this Division include, i. a., analyses of material resource flows (from deposit to waste) on global and local scales, the development of concepts and promotion of ecological economic policy, the development of sustainability indicators involving the concept of dematerialization, and environment-related valuation of products and services. The relatively recent tasks of the Division (since 1995) include the studies on the environmental policies in Central and Eastern Europe. The concepts of dematerialization on a narrower scale (Factor

Four, i. e., improving resource efficiency by a factor of four) and on a wider scale (Factor Ten, i. e., improving resource efficiency by a factor of ten) have been presented in the West to a large number of policy makers, scientists, businessmen and environmental non-governmental organizations, meeting with considerable interest.

The main purposes of the publication of the Report “Sustainable Development through Dematerialization of Production and Consumption. A Strategy for the New Environmental Policy in Poland” include:

- To present to the Polish readers the concept of demateralization of production and consumption as the most promising direction of actions for environmental protection in the next decades.
- To present the experiences of highly developed countries in the calculation of the total material requirement (TMR, TMR indicator). The methodology for the calculation of the TMR in the German economy was developed in Germany at the Wuppertal Institute for Climate, Environment and Energy (referred to as the Wuppertal Institute below).
- To present the results of calculations of the TMR for the Polish economy and to compare them with the results of calculations for the Netherlands, Japan, Germany and the United States of America. The TMR indicator for Poland was calculated applying the methodology provided by the Wuppertal Institute. The calculation work was conducted jointly by the Institute for Sustainable Development and the Wuppertal Institute in 1998-1999 under the Research Programme: “ECOPOL — Ecological Economic Policy — Strategy for Poland in the 21st Century”. The results of the work were presented at the Conference “Dematerialising Poland’s Economy — Outlook for the 21st Century”, organized jointly with the Ministry of Environmental Protection, Natural Resources and Forestry, which was held on 5 March, 1999, at the Ministry in Warsaw. It should be emphasized that Poland was the first country in Central and Eastern Europe where the said methodology was applied in practice. This Report is therefore a unique publication on these issues in the region.
- To present the strategy and instruments of dematerialization which can be used in the environmental and economic policies in Poland in the next years. This is of essential significance for the dissemination of the dematerialization concept among policy makers and the staff of the economic and environmental administration in Poland, and it can encourage the other countries in Central and Eastern Europe to undertake similar studies.

The issues of dematerialization of production and consumption, i. e., the reduction of the use of natural resources per unit product or service, became important for environmental policy as well as economic policy in the early 1990s when it was realized that the amounts of natural resources absorbed by the economy decisively determined the magnitude of damage to the environment and generated a variety of its degradation forms, which, to a large extent, were independent of the protective actions undertaken. It was found that the previous interventions which were mainly limited to the sphere where emissions would be generated were not sufficient for reducing the pressure of the economy and consumption on the environment. At present, we believe that it is indispensable to concentrate efforts on preventive actions “at the source” which are more effective and more justified, rather than on the dispersed and usually very expensive projects “at the end of the pipe”.

As a result of discussion conducted for a number of years by a group of experts in highly developed countries, a universal strategy was developed for gradually reducing material inputs on a global scale, above all in the most highly developed countries. At present, correct management no longer entails the reduction of traditionally understood *material intensity* in the economy only, but also *the total material intensity*, including, in addition to *direct material inputs* used in production or consumed, *indirect material inputs*, which are related to or result from the abstraction or displacement of the direct materials input.

For policy makers and economists, knowledge of the TMR should be just as important as knowledge of the Gross Domestic Product level. For this purpose, a group of experts from the Wuppertal Institute developed the concept and methodology for calculating *the total material requirement*, referred to as the TMR indicator in this Report. Using the TMR indicator, it is possible to answer the question whether from year to year the economy becomes more and more economical in the process of exploitation of the environment and more and more efficient as far as the use of the already extracted natural resources is concerned.

Thus, the essential point in the TMR methodology (TMR indicator) is the distinction *between direct material inputs* (DMI), and *hidden flows* which combine to form the material rucksack which accompanies direct inputs. The lowering of the level of the TMR is a desirable development. Lower hidden flows show that the pressure on the environment diminishes, whereas the reduced level of direct inputs is evidence to the improved environmental efficiency.

The key part of this Report is the information it provides regarding the results of calculations of the TMR indicator (and those of a few secondary indicators) for Poland, as well as the results of comparisons with the corresponding indicators calculated for some highly developed countries: the Netherlands, Japan, Germany and the United States. These comparisons demonstrate that still a large distance with respect to material productivity of the Gross Domestic Product remains between Poland and the highly developed countries in Europe, Japan and the USA.

Analysis of the Polish economy by using the TMR indicator and the related measures of material intensity confirms the thesis that essential and positive changes take place in the efficiency of using inputs extracted from the environment. What is disturbing is the rapid growth of material inputs in some categories (e. g., minerals), the distinct growth of imported inputs and above all the growing share of hidden flows in the TMR.

One of the most essential tasks of environmental policy is to develop a strategy and a set of instruments for dematerializing the economy which would be optimal under given socio-economic conditions. This Report shows a schematic diagram for the dematerialization strategy, showing the successive stages of the life cycle of a product: from the extraction of raw materials, through design and production, to the waste disposal.

The extent of identification and awareness of the issues related to the dematerialization concept are now much greater in the highly developed countries than in Poland. As a result of this, the scale and advancement of the implementation of the dematerialization strategy and instruments in these countries are much greater than in Poland.

To a slight degree, if at all, the economic instruments applied in environmental policy in Poland are suitable to dematerialize production and consumption. At the present stage of transition, the system of economic instruments mainly plays a fiscal and distributive role, serving only to a lesser extent to generate incentives for economical or more rational use of resources and materials in production and consumption.

The environmental policy instruments in Poland do not respond to the challenges posed by the modern, competitive and innovative market economy. In their macro- and microeconomic dimensions, the socio-economic policy instruments do not match the practical meeds for higher resource efficiency in the processes of production and consumption.

For this purpose, the system of economic and environmental policy instruments now in place in Poland should be much enhanced, in terms of both the set of instruments and their more consistent enforcement. It is indispensable to eliminate gaps in the system of identifying entities which use environmental resources and the mechanism of collecting environmental charges. Above all, a shift must take place in the strategy of influencing the economic system and the consumption sphere towards preventing the generation of pollution and the wasting of resources “at the source”. It is essential that criteria ensuring that material inputs may be reduced should be considered in the economic sphere even as early as when decisions are taken to invest, to begin production, to buy machinery, equipment, raw and other materials; and in the sphere of consumption, including mass consumption, as early as when purchases of consumer goods and service are planned. In Poland, such a system of economic and environmental instruments, or such a mechanism of incentives for producers and consumers are not yet in place, although, as mentioned above, some elements of this system are in operation, though in an imperfect or incomplete way.

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Glossary: Some concepts and definitions

Dematerialization

Absolute or relative reduction in use of nature (material and energy) per unit of output.

Factor 4

This is an objective whereby the input of natural resources, raw materials and energy in each unit of production is to be reduced to one quarter of its current level in the long term, over the next 20 to 30 years.

Factor 10

This is an objective whereby the input of natural resources, raw materials and energy in each unit of production is to be reduced to one tenth of its current level in the medium term, over the next 30 to 50 years.lk

Total Material Requirement (TMR)

This is an overall indicator developed by the Wuppertal Institute for Climate, Environment and Energy to describe, in terms of total tonnage, not only the amount of natural resources contained in the commodities produced by the economy, but also the hidden flows which are involved in such production. These material flows which remain outside of the economy include wood materials which are not used in logging (branches, needles, leaves and roots), earth and stone which is excavated in mining and quarrying along with usable ore and minerals, earthworks necessary in the construction of infrastructure systems (roads and communities) and erosion resulting from human activities (including intensive agriculture). The indicator may be used to assess the eco-efficiency of a national economy and realisation of the Factor objectives.

Total Material Input (TMI)	This indicator refers to the total amount of natural resources entering physically a (national) economy. It is, thus, derived from TMR by substracting the hidden flows associated with imported commodities.
Direct Material Input (DMI)	The flow of natural resource commodities that enterthe industrial economy for further processing. DMI is calculated as Total Material Requirement (TMR) less the domestic and imported hidden flows (ecological rucksacks)
Eco-efficiency	A social action strategy which seeks to reduce the use of materials in the economy in order to reduce undesirable environment impacts. Ever smaller quantities of materials have to produce a relatively higher degree of economic affluence which is more fairly distributed. The general objective of eco-efficiency is to “get more from less” (this is known as qualitative growth).
Eco-intensity	An indicator for the “use of nature” (Materials/ Energy/Pollution) per unit of output. A decrease of this indicator points to the right direction.
Eco-intelligent goods	Competitively priced services and products (Objects, tools machines, buildings and infrastructures) that yield maximum possible utility — in terms of individual customers preferences — for the longest possible time with a minimum of materials, energy, using of land, dispersion of toxic materials — from cradle to grave.
From Cradle to Grave	Life-cycle wide
Eco-intelligent production	Competitively priced technical and organizational procedures, conducted with the help of eco-intelligent goods while minimising the consumption of raw materials, energy, using of land, generation of waste or the dispersion of toxic materials.

Ecological rucksack	Ecological rucksack (hidden material flows) is the life-cycle-wide material input (MI) minus the mass of a product itself.
Material Inputs (MI)	Material inputs (MI) include all materials displaced by human activity, such as overburden, minerals, ores, oil, water, air etc. that are attributable to the life-cycle of a product or service.
Material Inputs Categories	Material inputs are calculated and presented by five main categories: abiotic raw materials, biotic raw materials, moved soil (e.g. erosion), water, air.
Material Flow Analysis (MFA)	This is an evaluation method which assesses the efficiency of use of material using information from material flow accounting. Material flow analysis helps to identify waste of natural resources and other materials in the economy which would otherwise go unnoticed in conventional economic monitoring systems.
Material Input per Service (MIPS)	This is a unit of measurement developed by the Wuppertal Institute for Climate, Environment and Energy whereby the material intensiveness of various products and services can be monitored in relation to a single commodity unit produced.
Physical Input-Output Table (PIOT)	A PIOT describes flows of material and energy which are extracted , transformed and discharged back into the environment by economic activities

Source: The Wuppertal Institute for Climate, Environment and Energy and also Ministry of the Environment (Finland), EUROSTAT "The Finnish Environment. Material Flow Accounting as a Measure of the Total Consumption of Natural Resources", Helsinki 1999, (Principal concepts: Eco-efficiency; Factor 4; Factor 10; Material Flow Analysis (MFA); Material Input per Service, (MIPS); Total Material Requirement, TMR).

Part 1: Towards a New Material Based Approach for Sustainable Development: Western Experiences

1.1 Dematerialization as a Strategy for Sustainable Development

The discussion of *sustainable development* which started in the second half of the 1980s focused attention on new environmental goals and raised questions for improving the efficiency of environmental policy. While a general definition of the term *sustainable development* does not exist, most definitions express the idea that development which should be *sustainable*, has to address environmental problems in a way preserving both the physical and social basis for future generations[1]. A continuation of production and consumption patterns as it exists in the industialized countries, and its adoption by developing countries will lead to the collapse of the Earth's life-supporting functions.

The essence of sustainable development is the connection of economic, ecological and equality targets. Economic prosperity should be achieved on the basis of efficient allocation, ecological longterm equilibrium and equal opportunities for present and future geerations. Ecological problems are related to economic activities and economic development. While traditional environmental policies have focussed attention on emissions and output effects, respectively, more recent approaches emphasize the importance of increasing resource productivity for solving environmental problems (Schmidt-Bleek 1994; von Weizsäcker/Lovins/ Lovins 1995; Wackernagel/Rees 1996).

The discussion of sustainable development directed attention to the physical volume of material and energy flowing through the economy as a primary cause for environmental problems. The structure of input and produced goods clearly determines the intensity of ecological problems. Almost any mechanical material displacement causes directly ecological changes without having to be transformed first into toxins, waste or emissions.

The growing "throughput" of material and energy flows is the primary cause for the majority of environmental problems (Baccini/Brunner 1991). In accordance with the laws of thermodynamics, the removal of resources from original

1 For an overview of the *Sustainability*-debate see: Bartelmus, P. (1999), Brown/Flavin/Postel 1991, Cansier 1995, Costanza 1991, Goodland/Daly/El Serafy 1991; Klemmer 1994, Schmidheiny, S. (1992), Tisdell, C. (1998).

locations, be it extraction of ores, overburden or use of water, causes irreversible changes in prevailing ecological equilibria. Most man-made ecological change cannot be technically reversed (Schmidt-Bleek 1994; Hinterberger/Luks/Stewen 1996). The ecosphere can hardly be repaired by human effort and all repairs are costly. Furthermore, it is not possible to use technologies that do not in one way or another change the environment. Further, the timescale is unknown over which ecosystem degradation may stretch before thresholds are irreversibly reached. The renewable resources are by no means exempt from ecological extraction costs, as they must usually be grown on plowed fields, irrigated, transported and processed. Ultimately this also means that every emission avoiding provision, every recycling effort, every solar collector and every disposal has its ecological costs.

Following the development of the basic methodology of MIPS (Material Intensity Per Service), to serve in calculating by weight the material flows corresponding to a given commodity or service over the whole life cycle of the commodity or the duration of the service, it became possible to compare countries and sectors (Schmidt-Bleek 1994). Just as in defining hidden flows, it should be stressed that the MIPS approach will not replace the studies on the toxicity of certain substances, land-use planning or the greenhouse effect. MIPS applies exclusively to the quantities of material inputs, thus providing information on the direct and indirect efficiency of resource use. Its application to commodities and services which satisfy demand enables consumers and producers to consciously shape their relationships with the environment.

Further research studies brought the formulation of a programme of actions designed to “dematerialize” production (Schmidt-Bleek 1994). Examples of possible reduction of energy inputs, more economical water use in paper mills, households and agriculture, limitation of industrial waste generation, incentives to use products with slight hidden flows and, finally, support to long- life products — these are only some of the practical suggestions which, it turns out, may lead to a fourfold reduction of the present energy and matter inputs in industrialized countries (von Weizsäcker et al. 1995). As a result, the “Factor Four” phrase — for economical use of energy and matter — has become a practical recommendation for the environmental policies of highly developed countries, which is expected to be topical for the next 40 years.

The OECD countries recognized such a substantial reduction of the matter stream to be a realistic and justified objective which ensured sustainability of economy. However, it may take a relatively long time to achieve this objective. With a regular reduction of resource use at a rate of 4.5% a year, the objective of a ten-fold decrease in the demand for natural resources could be achieved over approximately 50 years (Hinterberger 1997). It seems, however, that in the nearest future the annual use reduction cannot be so large, and, accordingly, the adjustment period will become longer. In addition, the achievement of the “Factor

Ten” objective will require a 90% reduction of direct and indirect uses, which seems to be possible only as an effect of a very distinct improvement in the efficiency of using the resources abstracted.

The present environmental policy focuses on correcting the critical stress and emission levels. To base economic decisions upon the recognition of critical situations is like to call the fire department, but it is not acting with concern for the future. In order to reach the enormous reduction requirements with respect to material-energy-throughput necessary for a sustainable development “normal” environmental policy will not suffice. According to Schmidt Bleek, President of the “Factor 10 Club”[2], we should “concentrate on megatons instead of nanograms to adequatly address regional and global environmental problems”.

To redirect economic development towards a path of sustainable development the present material flows should be reduced absolutely by about one half globally if one is to be on the safe side. Because about 20% of the world’s population living in the highly industrialized countries use 80% of the world natural resources, the industrialized countries have to increase their resource productivity by an average factor of 10 during the next 30 to 50 years — supposed the rest of humanity is to be granted an equitable access to natural resources (Schmidt-Bleek 1994; Carnoules Declaration 1995; see also Spangenberg 1995, BUND/Misereor 1995). This goal is equivalent to an annual increase in resource productivity of 4,5% for materials and about 3% for energy, and considered a pragmatic and feasible policy target.

Within one generation, nations can achieve a ten-fold efficiency increase concerning the use of energy, natural resources and other materials. The (long) timespan of fifty years is needed to allow the technical, social and economic dynamics to adapt and adjust without major conflicts with the requirements of economic sustainability. This is all the more necessary if, along side technology improvements, a culture of sufficiency is to emerge among the populations of industrial countries, accustomed to levels and forms and dynamics of well-being (Liedtke et.al. 1998).

The Factor 10 Club believes that such a goal is now technically feasible and, with appropriate policy and institutional changes, could become an economic reality (Schmidt-Bleek 1998).

Hence, new environmental policies in Western economies have to focus on increasing resource productivity (see the document of the World Business Council for Sustainable Development 1994, Netherlands National Environmental Policy Plan, Austria’s National Environmental Plan.

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[2] The “Factor 10 Club“ is an international body of senior government, non-government, industry and academic leaders existing since 1994 in Carnoules, France.

Efficient environmental policy requires a new policy design: strong orientation towards increasing resource efficiency and increasing the role of market forces and competition as a strategy for higher cost consciousness and a higher rate of innovation (Hinterberger/Luks/Stewen 1996, Köhn/Welfens 1996). The dematerialization concept provides ecological guard-rails for long term economic development. In this way the individual actors as well as policymakers are provided with tools for decision-making. Here the dematerialization concept provides more advantages than traditional policies aiming to solve specific environmental problems. It provides common rules for decision-making understandable and relevant for *all* at the same time.

1.2 Total Material Requirement (TMR) — An Indicator to Measure the Material Basis of National Economies

Valid and comparable physical data about material and energy flows is a precondition for achieving environmental sustainability. At present only a few countries generate an annual material flow statistics: Germany, Japan, the Netherlands and the United States (Adriaanse et al. 1997, 1999; Bringezu 1998, Bringezu 2000).

The Wuppertal Institute in Germany developed a methodology of material flow accounting (Schmidt-Bleek et al. 1998) which can be considered as an operationalization of Herman Daly's concept of throughput (Hinterberger, Luks 1998). Measuring material inputs is an operationalization of scale. By including "ecological rucksacks" or "hidden flows", material input is the total material and energy flow (in mass units like kg or tons) and includes not only the materials converted within the economy but also those "left aside" e.g. at mining sites.

The methodology from the Wuppertal Institute allows to estimate the **Total Material Requirement (TMR)** for a national economy, including all domestic and imported natural resources (Bringezu 1998, Bringezu 2000). The input approach concentrates on the sources of matter-energy-flows, as opposed to the emphasis on emissions of the environmental policies currently in practice. The method is used to provide a comprehensive overview of the physical basis of industrial economies and to derive indicators for sustainable development.

The TMR is the sum of the direct material input and the hidden or indirect material flows, including deliberate landcsape alterations. The TMR gives the best overall estimate for the potential environmental impact associated with natural resources extraction and use. The TMR can be split into **direct materal input** (**DMI**) and **hidden flows** (Adriaanse et al, 1997, p.8):

- **Direct material input (DMI)** is the flow of natural resource commodities that enter the industrial economy for further processing/consumption. Included in this category are e.g. grains used by a food processor, petroleum sent to a refinery, metals used by a manufacturer, automobiles for sale etc.

- **Hidden material flows** are the portion of the total material requirement that is not included in the commodity itself. The hidden material flow of primary materials comprises two components: ancillary flows and excavated or disturbed flows.

1.3 TMR in Countries of the Western World

Trends in natural resource use in Germany, Japan, the United States and the Netherlands are presented in the report **Resource Flows: The Material Basis of Industrial Eonomies (**edited by the World Resources Institute, the Wuppertal Institute; the Dutch Ministry of Housing, Spatial Planning and Environment and the National Institute for Environmental Studies in Japan. All of the four countries are highly industrialized countries with high standards of living. They vary in the size of their populations, economies and land area.

The TMR of USA, Germany, Netherlands and Japan was investigated with respect to its per capita levels over the time period 1975 to 1994, its major material components by groups, its direct vs. indirect inputs, and its domestic vs. foreign components. The results for these four basic indicators will be described later in this study in the context of and comparison with TMR results for Poland.

Trends in overall materials intensity were measured by the TMR/GDP ratio. As a general trend, the analysis shows a declining pattern of materials intensity in all countries, supporting the conclusion that a modest decoupling is taking place. The decoupling trend would be even stronger if the effects of the German reunification were removed.

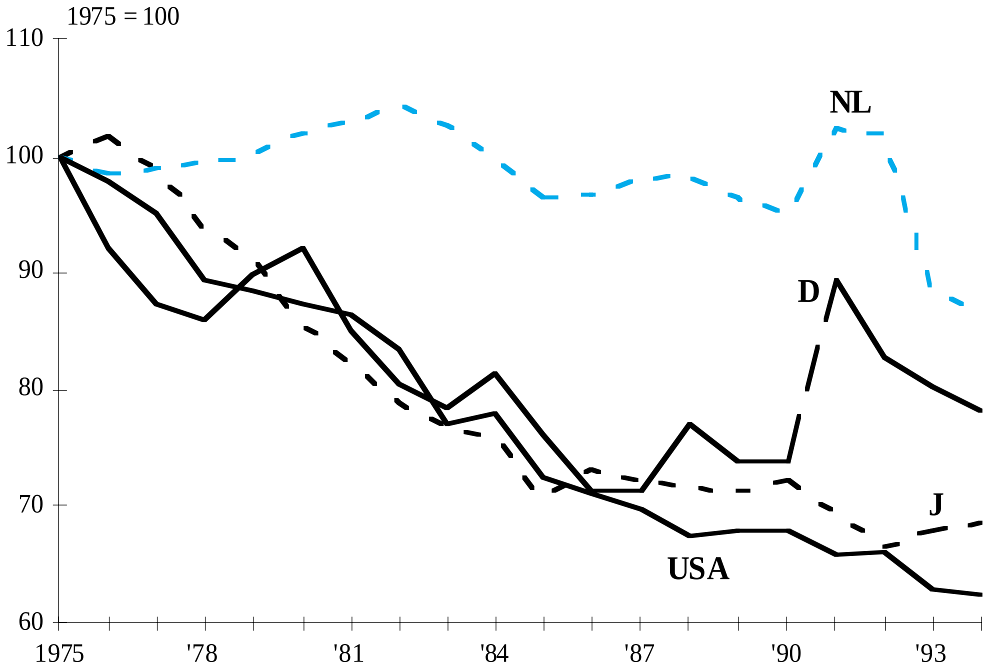

Figure 1.1: Overall material intensity (TMR/GDP), index
Note: Change from 1990 to 1991 is due to German reunification and its statistical consequences.
(Source: Bringezu 1998, based on Adriaanse et al 1997 with revised Dutch data)

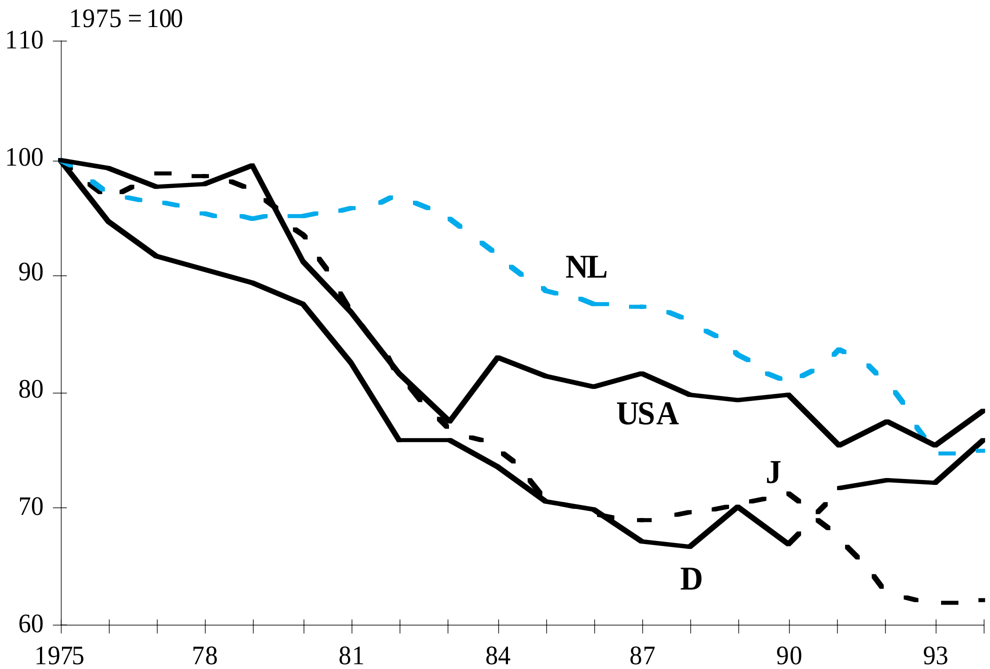

Figure 1.2: Direct input materials intensity (DMI/GDP), index
Note: Change from 1990 to 1991 is due to German reunification and its statistical consequences.
(Source: Bringezu 1998, based on Adriaanse et al. 1997 with revised Dutch data)

The DMI/GDP ratio, a measure for the direct input intensity, resulted in a pattern showing a modest decline in intensity followed by a leveling-off the past decade, which implies that direct inputs of natural resources are now growing in parallel with economic growth.

However, the TMR/GDP ratio provides the best measure of a country's material intensity or overall eco-efficiency. This indicator is a useful tool to track progress toward decoupling natural resource use from economic activity. The DMI/GDP ratio can signal the presence or absence of technology related changes or industrial practices that increase the efficiency of materials use.

An interesting results provides an analysis of the 1993 TMR/GDP ratio: the U.S., German and Dutch economies require, respectively 3.4, 3.3 and 3.2 kilograms of physical inputs per Dollar of GDP. Japan has a lower intensity of 1.4 kilograms per Dollar.

Structural analysis

Moll et.al. (1998; see also Hinterberger 1998) investigated the changes in level and structure of economic indicators and material throughput of the German economy between 1980 and 1990. While material flows (in terms of TMR) increased only by 0.8% in that period, GDP grew by 25%. A decomposition analysis shows that *ceteris paribus* this would have increased TMR by 13% while structural changes forced TMR to decrease (by 22%). Additionally, resource extraction technologies became more inefficient, which again *ceteris paribus,* would have increased the German TMR by 8%.

What is of interest is that the accountability of different sectors has important political implications, since knowing the composition of the overall material use means knowing where ecological economic policy can intervene with possibly best results (see Moll et.al. 1998, pp. 31f.; Hinterberger/Luks 1998, p. 11).

Table 1.1: Industries with increasing/decreasing material flows, West Germany 1980-1990,

Sectors with increasing TMR **plus**
non ferrous metals and non ferrous metal products 70,9%
production of road vehicles 24,0 %
electric power, steam, hot water 49,7%
musical instruments, toys, sports equipment, decoration 47,1%
electrical machinery and equipment 28,7%
chemical products 19,9%
Sectors with decreasing TMR **minus**
coal and products of coal mining 69,4%
iron and steel 20,2%
building and civil engineering work 14,4%
installation and building completion works 18,9%
products of mining (excluding coal, petroleum and gas) 46,6%
foundry products 33,3%

Source: Hinterberger 1998

Part 2: Applying the Material-Based Approach to Central and Eastern European Countries

2.1 Why to Promote the Dematerialization Approach for Central and Eastern Europe (CEE)?

Dematerialization in Europe cannot reach its aim without considering the situation in the countries of Eastern Europe, where Visegrád countries record high growth rates and therefore experience rising environmental pressure of industry and from growing traffic. Dematerialization in Western Europe will be accompanied by increasing resource use in the new transforming economies, their effects can be reduced or neutralized. In CEE a substantial dematerialization potential exists: the excessive resource use which has its roots in the general inefficiency of the non — market allocation mechanism, can be improved through market mechanism (Welfens 1993a, Welfens 1999).

The extent of the necessary dematerialization effect in CEE countries needs not to be so high (Factor 10 or more) as in the Western industrialized countries. This is due to the fact that leading edge technologies are often not available or unprofitable. However, given the large technological backlog in Eastern Europe rapid technological catching up and therefore high productivity growth is possible (Welfens/Welfens 1994). Dematerialization could be a new element of environmental policy also in these countries. Increasing resource productivity with the aim of dematerializing and of promoting waste minimization and recycling practices could be a fundamental part of a sustainability path for CEEs.

A new environmental strategy for Central and Eastern Europe should comprise three elements:

- increasing resource productivity with the aim of dematerialization as *fundamental* part of a future environmental strategy;
- pollution management as an *additional* element which is necessary in every environmental policy, but which can not solve strategic issues;
- improved land-use management

The aim of any new environmental strategy should be to shift the economic development away from maximising throughput (physical volume of inputs and outputs flowing through the economy) onto achieving a higher resource efficiency both for the input side and the output side. This requires a higher economic benefit to be spent from a given throughput (Daly 1992).

Some aspects of increasing resource productivity are discussed in CEEs (Bochniarz/Bolan 1991; Baumgartl 1996; REC 1994a; Zylicz 1994), but this way of acting and thinking is novel in the new transforming economies.

Dematerialization requires a mix of instruments in which positive aspects of each instrument should be used, at the same time minimising the expected negative side-effects. This should induce long term structural changes towards an ecologically sustainable path of development. The structural change induced by a policy of dematerialization will produce winners as well as losers and will leave spaces where market solutions will not emerge. In these fields additional policy measures will be necessary.

All instruments of the traditional environmental policy should be checked, whether they are useful for dematerialization goals; some instruments should be redesigned e.g. new (green) taxes or eco-subsidies.

2.2 TMR for Poland: adoption of the Western methodology

The methodology adopted in this paper for an evaluation of the material intensity of natural resource use was originally proposed and applied by the Wuppertal Institute for Climate, Environment, Energy. This means that the this paper concentrated on the material inputs abstracted from the environment to enter production processes and the sphere of consumption. In keeping with the adopted principal idea, the size of material inputs is considered to be an important, though certainly not the only one, indicator of the intensity of economic pressure on the environment and the economic efficiency of environmental resource use (Schmidt-Bleek et. all 1998).

The basic scheme for the analysis of material flows in the economy is the system of the Physical Input-Output Table — PIOT. Within this table, three categories of material flows are distinguished: raw materials, products and others/residuals. As numerous domestic balance schemes in the references show (Adriaanse et al. 1997), they are grouped in four blocks corresponding to the following categories: import, material input, material output, export.

The construction of the complete PIOT for Poland is a matter for the future. At the present stage, the most important task was to collect data required for the calculation of the indicator called TMR (Total Material Requirement). Under the adopted methodology, the calculations of the TMR indicator itself would require knowledge of the first two flow categories, i.e., domestic and imported flows/material inputs.

The available publications and materials, above all the presentation of the idea (Schmidt-Bleek et. all 1998), the TMRs calculated for several highly industrialized countries (Adriaanse et al. 1997) and the detailed study from the seminar conducted by the Wuppertal Institute (Schütz, Bringezu 1998) give an idea of the method and range of data required for the construction of a comparable TMR for Poland. It should be stressed, however, that official publications provide only a general view of the problem, since, e.g., even expanded tables devoted to individual countries (Adriaanse et al. 1997) present only groups of inputs under consideration, and, thus, they show figures which are final results rather than raw data taken for calculations.

The more recent paper “Economy-wide Material Flow Accounting (MFA), Technical Documentation” (Schütz, Bringezu 1998) went a step further, to show which types of inputs were taken into consideration in Germany. There, the types of inputs considered were calculated along with instructions for the manner of measurement of and approach to the quantities of inputs in successive calculations. The paper “Technical Documentation” shows how the data base on material inputs in Germany is gradually complemented and improved. Individual categories of inputs can be presented in greater detail; and, primarily for domestic inputs, this should lead to increasingly exact estimation of the total material requirement.

In the TMR methodology, the basic issue is the distinction between direct and indirect inputs. As a rule, the acquisition of a specific amount of resource — to become later a direct input — involves a significant disturbance of the state of the environment. Some changes reflect the simple, quantitative effects of the abstraction of the used resource. In contrast, the other transformations result from the manner of acquisition and the efficiency of this process; thus, they are as if an indirect input, in fact, the external effect of the abstraction of a used input.

The part of the resource used in production and further consumed is usually only part of the total abstracted matter, as it also consists of the part of the resource that is useless from man’s point of view. Since it has no commercial value, it will not be used further, to remain somewhere in the environment; this, however, means that the resource has been reduced and the state of the environment has been disturbed in quantitative terms. In addition, the very abstraction process is usually accompanied by a variety of disturbances of the state of the environment, which should also be interpreted as indirect, though economically useless, inputs.

Under the TMR concept, the purpose of the category of *“hidden flows”* is to reflect the size of indirect inputs, which are a burden on the environment, although they are not present on the market and usually do not bring benefits. If indirect inputs are very large, this means that a given type of economic activity should be recognized to be excessively material-intensive, irrespective of the fact that the direct input may be small and provide tangible benefits. If, as a result of this, the total material requirement is high, it is also an indication that the exploitation of the resource is a pillage, since it degrades the environment and is in contradiction with the principles of sustainable development.

To date, in the foreign publications, the estimated indirect inputs related to the individual categories of inputs have been called “ecological rucksack” (a literal translation of the German term *ökologischer Rucksack* or the American term *ecological rucksack*). It seems, however, justified to point out that indirect inputs are a measure which refers to mass only, and specifically to the excessive exploitation of the matter abstracted from the environment, and, therefore, they cannot serve in evaluating other forms of degradation of environmental resources, e.g., toxicity or radioactivity of matter returned to the environment. Their relation to a variety of environmental factors is limited and, therefore, it would be more appropriate to apply the term “mass rucksack”, with the underlying sense of material mass, as proposed by von Weizsäcker; *mass rucksack* in the original (von Weizsäcker 1998).

Further on, indirect inputs will continue to be represented by the conceptually abridged term **hidden flows**. This term is proposed as one representing best the meaning of the material quantity, defined by weight, which is a burden on the environment as a result of man’s economic activity.

The hidden flows are less frequently calculated on the basis of available, published data on indirect inputs and more frequently on the basis of recalculation factors, i.e., *special hidden flow coefficients* as determined in empirical studies or as a result of analyses of statistical data. In the Polish study, to a large extent, use had to be made of the hidden flow coefficients collected at the Wuppertal Institute.

The 1994 publication by Schmidt-Bleek can provide an exhaustive explanation why careful attention should be paid to the quantities of material inputs absorbed by man’s economy (Schmidt-Bleek 1994). The analysis of the close to exponential increase in the use of most metals over the last two hundred years shows that the depletion of resources is not the only problem. As earlier studies (Kneese, Ayres, d’Arge 1971) and most recent publications of the Wuppertal Institute for Climate, Environment, Energy demonstrate, to a large extent the destruction of the environment depends on, both directly and indirectly, on the mass of materials abstracted from it.

Apart from positive signs, among others, undoubtedly the development of recycling and the emergence of industries which re-use, dispose of and treat waste, on a global scale the economy still involves excessive high material-intensity. On the one hand, the technical progress related to resource abstraction reduces the self-evident losses which occur in the course of mining processes, but, on the other hand, it makes it easier to use resources more cheaply and faster. Without saving-oriented restrictions there can be only one outcome: the depletion of resources and the ever growing degradation of the land surface, along with all the effects of these.

Ecosystems are destroyed in a variety of ways. Primarily, it involves immediate quantitative and qualitative changes as well as the slowly cumulating effects of intensive exploitation of environmental resources. As an effect, the excessive resource abstraction, i..e., excessive with respect to the direct consumption of resources, causes greater than justified releases of hazardous substances, mainly heavy metals or environment-acidifying chemicals, into the environment. As an example, scientists suspect that the problem of soil acidification, which has been given much attention, is to a larger extent caused by soil erosion accompanying the destruction of the land surface than the combustion processes themselves, with their related emissions of sulphur dioxide and nitrogen oxides.

The extensive open-pit mining of mineral resources is still relatively common, contributing to the degradation of the land surface, with its environmental effects exceeding the local changes in the environment. Intensive agriculture causes soil erosion. The takeovers of the land surface for economic purposes, including those of mining, agriculture, building and transport infrastructure, are further examples of pressure, which, despite its obviously harmful effect, is only to a slight extent controlled and restricted.

The magnitude of hidden flows is not commonly known as it should, since this magnitude warrants the conclusion that the robber economy is still in place and the most developed countries of the world are wasteful (von Weizsäcker 1998). As an example, for gold and platinum the ratio between the pure metal used and the hidden flow is about 1:300,000. This means that the burden of a hidden flow for a wedding ring with its weight not exceeding 10 grams is about 3 tons. The hidden flows for energy carriers are also very significant. For hard coal, hidden flow is on average five times greater than the coal input to be used directly in the economy, while for brown coal this hidden flow may be even ten times greater. One liter of orange juice involves a hidden flow of 100 kg, the rucksack for an average newspaper is 10 kg, and the production of a passenger car cause the generation of almost 15 tons of solid waste, not to mention water consumption.

Most people tend to associate the sustainable management of natural resources with revolutionary changes in the social and economic spheres of life. Indeed, in many cases this is inevitable and will not happen soon. However, the approach in question, consisting in dematerialization of production processes, difficult and finance-requiring though it is, may lead to optimistic conclusions in the scope of sustainable resource use, even including non-renewable resources. For this purpose, a simple calculation example can be considered.

It may be assumed that a certain depleting resource is approximately 1000 times larger than the current annual consumption: such an assumption is legitimate with respect to fossil fuels (Binswanger 1998). It is possible to use a formula for the sum of a geometrical series, where “R” is the quantity of the resource, “i” is the rate of the resource consumption and “a” is the current level of the resource consumption, with “a” given the value of 1 (one thousandth of the resource in question) in the further part of the calculation example:

$$R = a[1 + (1+i) + (1 + i)^2 + ... + (1 + i)^{n-1}] = a[(1 +i)^n - 1]/i.$$

It turns out that if consumption continues to grow at an annual rate of 0.5%, the resource will be depleted in 360 years. If the consumption increase is 5% a year, as soon as after 81 years of such exploitation the resource will vanish. The maintenance of the consumption at a constant level equal to the current one (a = 1) will extend the period of use of the resource to 1000 years. If, following efforts to reduce the consumption, the annual reduction rate is 0.05% (with the growth rate of -0.05%), the exploitation period will be extended to almost 1500 years. Thus, all fits the expectations: the reduction of the consumption pressure ensures a longer time when benefits from a resources can be enjoyed.

However, using the mathematical dependence in hand between the amount available and the rate of its depletion, it can also be calculated what rate of consumption drop may ensure the infinite period of resource use (sic!). The answer which the calculation provides is as follows: an annual consumption drop by 0.1%, i.e., 1/1000 of the current consumption, will suffice for a depletable and non-renewable resource to exist forever (Binswanger 1998). Is it a realistic calculation? It is acceptable, since the annual consumption drop by 0.1% signifies that after 100 years the consumption should fall by 10%, and after 500 years it should decrease by 40% compared with the current consumption level; the resource consumption level in the year “n” is defined by the formula $a(1 - 0.001)^n$, with the consumption decrease with respect to the base year given by the formula $a - a(0.001)^n$.

It should be noted that the reduction of resource use in the numerical example given, which is desirable from the point of view of sustainable economy, occurs in a longer period than the one expected by the authors of the “Factor Four” and “Factor Ten” programmes. Possibly, they did not consider the sustainability of resource use in similarly formalized and absolute terms. It should be noted, however, that, to an economist, the extension of the use time of a non-renewable resource, say, to 10,000 years instead of the expected several dozen years, is a perspective of duration which is close to infinity.

Coming back, however, to the calculation and on the basis of the assumption that dematerialization would be commonly applied in the industrialized countries which are the main consumers of fossil fuels, it seems possible to reduce their consumption by more than 0.1% in the first years of their more economical use. In such a case, the reduction of material inputs over the next 100 years would correspond better to the German scientists’ guideline that the consumption should drop by 50% on a global scale.

In conclusion, the idea of sustainable use need not to be the domain of futurologists and fanatical defenders of the environment who demand radical and hardly popular changes. The measures of implementation are within reach, although only the future generations may be able to watch the happy ending. The apparently too simple and hardly spectacular call for a gradual drop in the use level of environmental raw resources is one of the major routes which may lead to sustainable development.

2.3 TMR for Poland: A Comparison with the TMR for Developed Western Countries

On the basis of the results of the total material requirements for Germany, the USA, the Netherland and Japan (Adriaanse et al. 1998) and Poland (the author’s own elaboration after Adriaanse et al. 1998, Schütz 1999) interesting comparisons can be made (see below: figures 2.1. – 2..4.). The study of Adriaanse et al. 1998 covered the period 1975-1994 for which basic indicators TMR and DMI as well as those derived from them were determined. It turned out that in the initial part of the period TMRs per capita varied very much for the countries under study — from nearly 100 tons per capita in the USA to less than 40 tons per capita in Japan. With the passage of time, the difference between the indicators became smaller — with the indicator for Japan growing to 45 tons per capita and those for the other countries dropping to 75-85 tons per capita.

A closer look at the structure of inputs in 1991 shows that the differences between the countries under study are large and unaccidental. In Germany and the USA, the levels of TMR per capita are determined by their use of fossil fuels, almost 40 tons and almost 30 tons per capita, respectively. In the Netherlands, the inputs related to metals and the metal-forming industry are very important. In the Netherlands and the USA, soil erosion caused by agriculture distinctly affects the value of TMR per capita. In the USA and Japan, building and the construction of roads and motorways make a greater contribution to an increase in TMR than in the other countries. In Japan, the quantities of the leading inputs — metals and the metal-forming industry, fossil fuels, building materials, inputs related to the construction of infrastructure — were surprisingly close in quantitative terms, with none of them exceeding 15 tons per capita.

In 1991, the proportion of hidden flows in the calculated values of TMR per capita varied between 55% and 75%. It was the highest for the Netherlands and Germany and the lowest for Japan. There were very different relations between domestic and imported total material requirements, including direct inputs and hidden flows. In the USA, domestic inputs dominate the TMR of 84 tons, with only about 5 tons represented by imports. The situation is opposite in the Netherlands, where import-related material inputs substantially dominate. In Germany, imports account for slightly more than 30 tons out of the TMR per capita weight of 86 tons. In Japan, the relations between domestic and imported material inputs are balanced, with imports being slightly larger.

The data collected for Poland refer to 1992, only slightly limiting the possibility of comparing the results obtained (Table 2.1.)[3].

Table 2.1: Comparison of material input indicators for 1991

Material input	**Poland***	**Japan**	**Nether-lands**	**Ger-many**	**USA**
Domestic DMI (million t)	453	1,424	236	1,367	4,581
Imported DMI (million t)	39	710	303	406	568
Total DMI (million t)	492	2,133	539	1,773	5,149
DMI per capita (t)	13	17	32	22	20
Domestic hidden flows (million t)	485	1,143	69	2,961	15,494
Imported hidden flows (million t)	88	2,439	632	2,030	594
Total hidden flows (million t)	573	3,582	701	4,991	16,088
Hidden flows/DMI	1	2	1	3	3
TMR (million t)	1,065	5,716	1,240	6,764	21,237
TMR per capita (t)	28	46	79	86	84

*Data for Poland come from 1992

Source: Sleszynski and Schütz 1999 (unpublished); Ine 1999

Detailed comparison of Poland (1992) and Germany (1991) leads to several interesting conclusions. For such categories of inputs as the hidden flows for domestic metal ores, fisheries, soil erosion, forestry production, game hunted, energy carriers and primarily the production of domestic metal ores, the proportion of Polish inputs is greater — they are greater per capita in Poland than in Germany. There is an opposite situation for the other categories of inputs.

As a result of the calculations performed, it was possible to determine that TMR for 1992 was 1,065 million tons, with 492 million tons being the direct material input, i.e., DMI. Thus, TMR per capita was 27.7 tons, with the respective DMI per capita of 12.8 tons. These values are distinctly lower than in those observed in the highly developed countries; this can be explained by the lower level of economic activity.

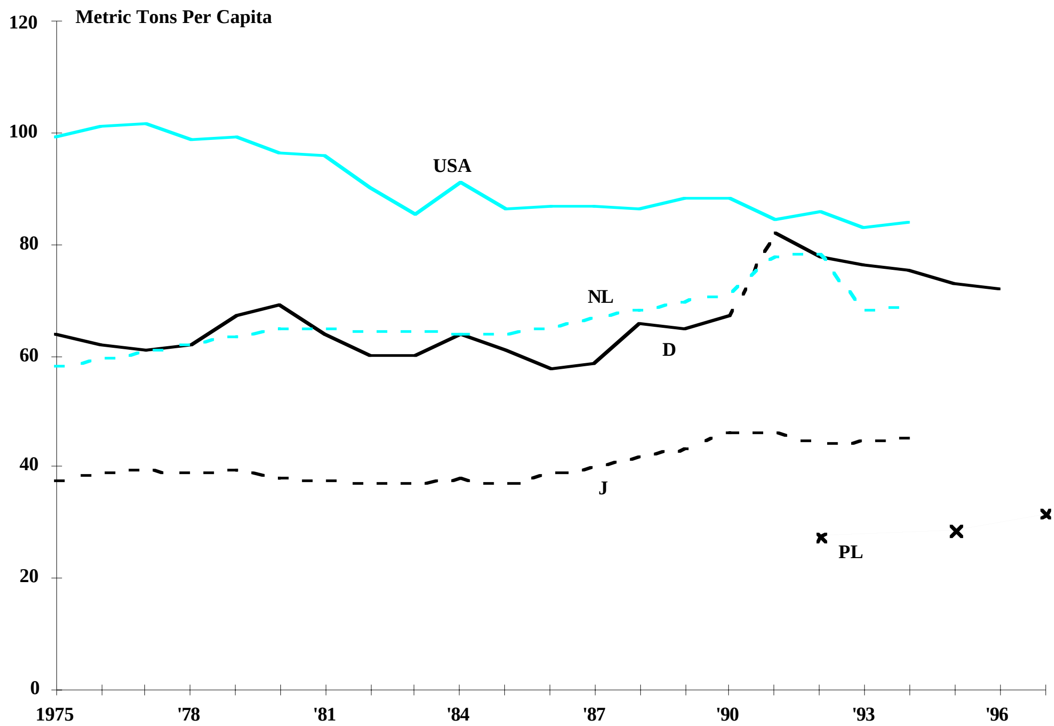

Figure 2.1: TMR for the USA, Netherlands, Germany, Japan and Poland — annual flows per capita. Change from 1990 to 1991 is characterized by the German reunification and its statistical consequences.
Source: Bringezu 1998, based on Adriaanse et al. 1997 with revised Dutch data; Polish data (1992 – 1997): Sleszynski and Schütz 1999 (unpublished); Ine 1999

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3 See also the tables in Annex 2, that show detailed data on material inputs and hidden flows expressed in tons and recalculated per capita.

Just as in other countries, the greatest contribution to the size of TMR per capita is made by energy carriers, for which the direct input per capita is 5.25 tons and the respective hidden flow is 6.81 tons. Essential parts are also played by direct mineral inputs - 3.09 tons, soil erosion caused by agriculture - 2.59 tons, land surface disturbances - 2.45 tons and agriculture - 2.17 tons per capita.

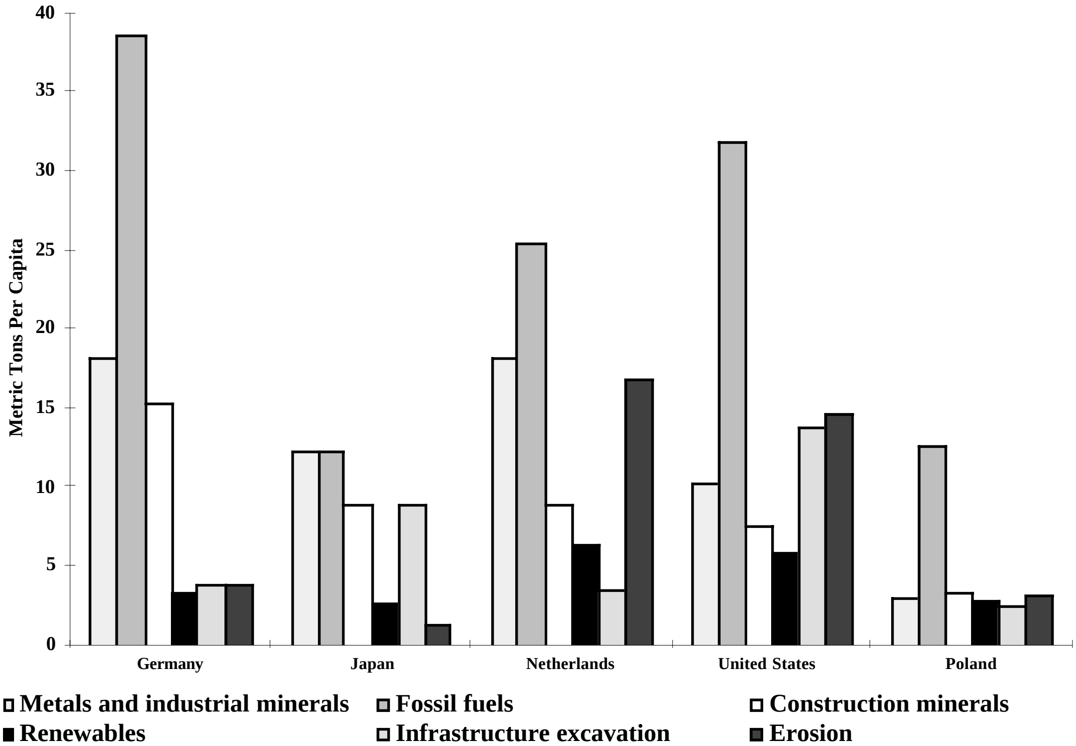

Figure 2.2: Primary contributions to TMR: the USA, Netherlands, Germany and Japan 1991, Poland 1992.

Source: Bringezu 1998, based on Adriaanse et al. 1997 with revised Dutch data; Polish data: Sleszynski and Schütz 1999 (unpublished); Ine 1999

The proportion of hidden flows in the calculated TMR per capita was about 54%, thus, it was largely close to those observed in the industrialized countries. 28 tons of TMR per capita consisted of less than 13 tons of direct inputs and close to 15 tons of hidden flows. In addition, in the Polish case, domestic inputs distinctly dominated. Out of 28 tons of TMR per capita, more than 24 tons were domestic inputs and only less than 4 tons were imported inputs.

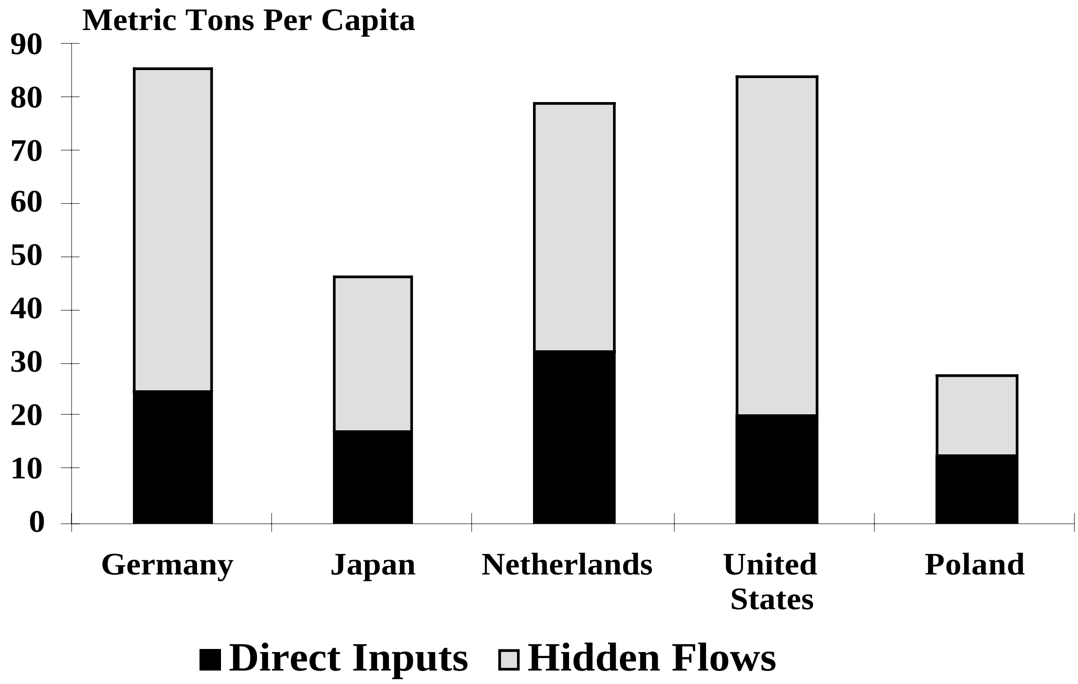

Figure 2.3: Direct inputs and hidden flows as a proportion of TMR; the USA, Netherlands, Germany and Japan 1991, Poland 1992.
Source: Bringezu 1998, based on Adriaanse et al. 1997 with revised Dutch data; Polish data: Sleszynski and Schütz 1999 (unpublished); Ine 1999

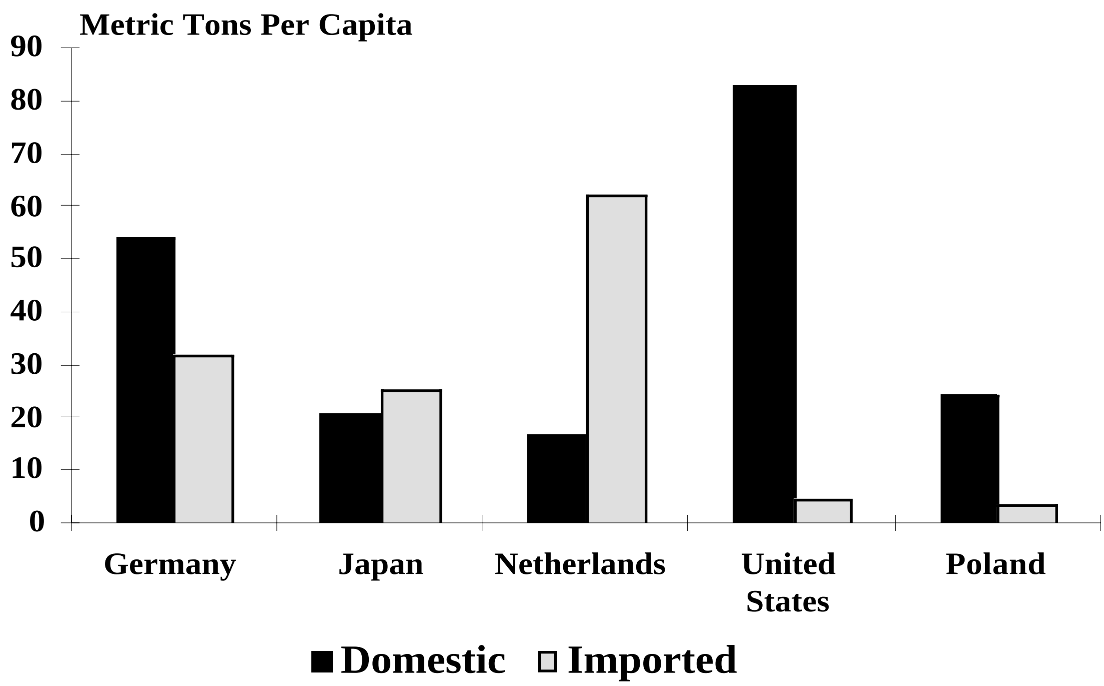

Figure 2.4: Domestic and foreign components of TMR; the USA, Netherlands, Germany and Japan 1991, Poland 1992.
Source: Bringezu 1998, based on Adriaanse et al. 1997 with revised Dutch data; Polish data: Sleszynski and Schütz 1999 (unpublished); Ine 1999

The collection of the statistical data for the three years made it possible to perform a preliminary assessment of the trends which occurred in the Polish economy over 1992-1997 (see data in annex 2 and below figures: 2.5. – 2.7.). For the main indicators, it was found that TMR and DMI grew. TMR was 1,065 million t in 1992, 1,092 million t in 1995 and 1,226 million t in 1997. There was similar growing trend for DMI; 492 million t in 1992, as much as 533 million t in 1995 and 541 million t two years later. Given the slight population changes, the indicators TMR and DMI per capita grew at a similar rate. In the period in question, DMI per capita grew from 12.8 t to 14.0 t, and TMR per capita from 27.7 t to 31.7 t. That growing trend resulted directly from the growth in economic activity and the corresponding growth in production and consumption.

There was a positive gradual change in the value of indicators of the efficiency of using material inputs acquired from the environment. The TMR/GDP indicator, expressed in kg per 1 USD of the Gross Domestic Product, fell in the period under study. In 1992, it was 12.63 kg; in 1995, it was distinctly less, i.e., 8.78 kg; and in 1997, it improved slightly, to the value of 8.57 kg. It is interesting to note that the analogous indicator for direct inputs, i.e., DMI/GDP (kg per 1 USD of GDP), showed even a more distinct improvement. In 1992, it was 5.83 kg, in 1995 it fell to the level of 4.22 kg and, two years later, it dropped to 3.78 kg.

The measures GDP/TMR and GDP/DMI can be obtained by reversing the formula for the indicators discussed above. Then, it can be said that from 1992 to 1997, due to systemic changes in the economy, one ton of material inputs generated an increasingly larger value of the Gross Domestic Product. In 1992, one ton of total material requirement was sufficient to generate 79 USD of GDP, whereas in 1997 this one ton would produce 117 USD of GDP. A dynamic growth was even more distinct for DMI: 171 USD of GDP in 1996 and 264 USD of GDP in 1997.

These positive trends cannot, however, conceal the real distance between the Polish economy and the substantially more efficient economies of the other analyzed countries. Thus, in 1992, the levels of the indicators TMR/GDP for Germany, the Netherlands and the USA only slightly exceeded 3 kg per 1 USD of GDP, i.e., they were almost four times lower than the Polish indicator for the material intensity of GDP. The case was similar with the indicator GDP/TMR, which was 450 DEM per ton in Germany in 1992, i.e., it was also several times greater than the Polish indicator for resource productivity.

Table 2.2: Material inputs in the Polish economy in 1992-1997

	1992	**1995**	**1997**
TMR (million t)	1,065	1,109	1,226
– domestic TMR	938	910	946
– imported TMR	127	199	280
TMR per capita (t)	27.7	28.7	31.7
DMI (million t)	492	533	541
– domestic DMI	453	481	479
– imported DMI	39	52	62
DMI per capita (t)	12.8	13.8	14.0
Hidden flows (million t)	573	576	685
– domestic hidden flows	485	429	467
– imported hidden flows	88	147	217
Hidden flows per capita (t)	14.9	14.9	17.7
TMR/GDP (kg/USD)	12.63	8.78	8.57
DMI/GDP (kg/USD)	5.83	4.22	3.78
GDP/TMR (USD/t)	79	114	117
GDP/DMI (USD/t)	171	237	264
DMI/TMR (%)	46	48	44

Source: Sleszynski and Schütz 1999 (unpublished); InE 1999

In general, analysis of the size of material inputs in different sectors of the economy (see annex 2) confirms the overall growing trend for TMR. It should be noted that over the period under study there were only minor changes in the most weighty (literally and figuratively) category of domestic energy carriers. The direct inputs were 202 million t in 1992, almost 205 million t in 1995 and slightly more than 205 million t in 1997. In contrast, the level of hidden flows related to domestic energy carriers fell: from 262 million t in 1992 to 236 million t in 1997.

A gradual growth could be observed for most categories of domestic material inputs; in 1995-1997 it was, however, very slight or stopped, even to fall in some categories (annex 2). The situation of such input categories as the hidden flow for domestic mineral production and the disturbed land surface was different. In 1995-1997, too, inputs rose very substantially for these categories.

In the most recent period, the quantities of imported direct inputs and hidden flows grew. This is true primarily for energy carriers, metals and minerals, but also for processed products of forestry and the hidden flows for agricultural production.

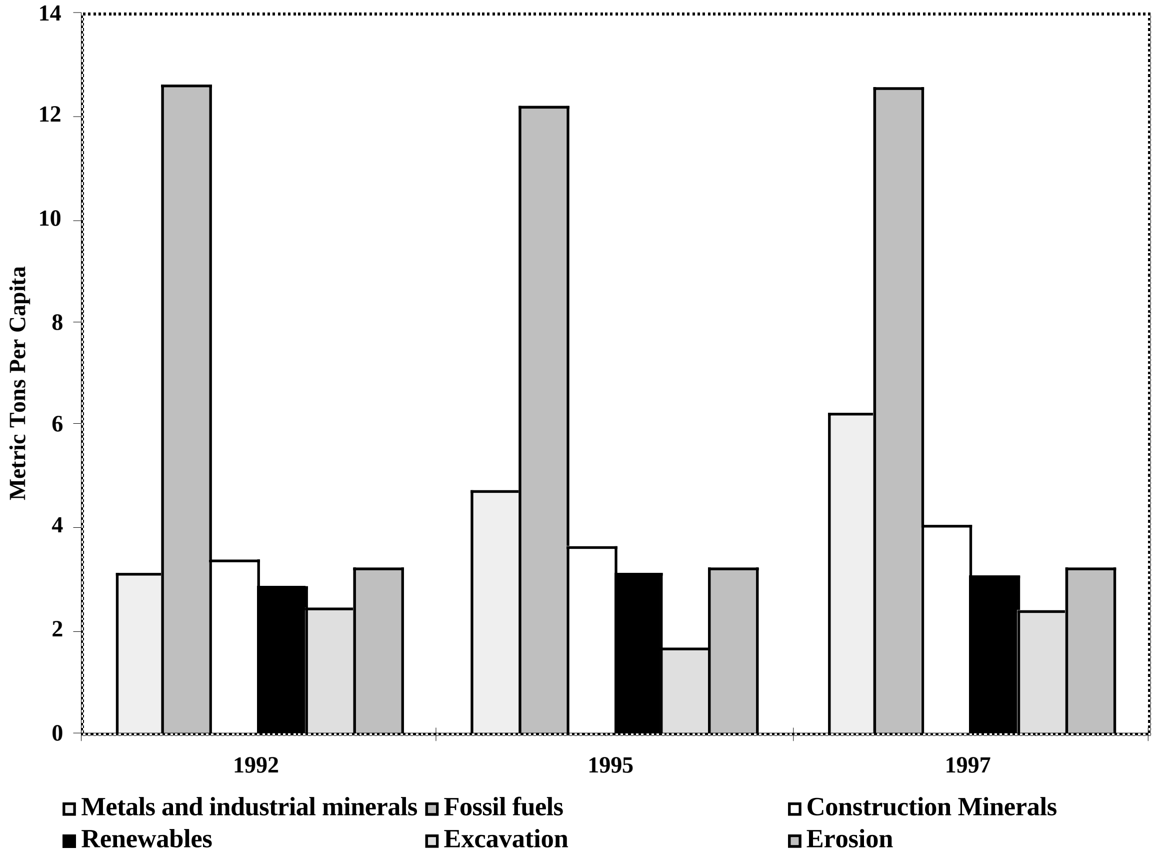

Figure 2.5: The structure of the Total Material Requirement in Poland according to input categories, 1992-1997.
Source: Sleszynski and Schütz 1999 (unpublished); InE 1999

It is difficult to give an unambiguous answer regarding the structure of the Total Material Requirement (figure 2.6.). Analysis of the proportion of direct inputs in TMR may suggest that their trend is hardly favourable, particularly in the last period. In 1995, the indicator DMI/GDP was 48%; and in 1997 it was lower. i.e., 44%. This means that hidden flows carry increasing “weight” in affecting the size of the Total Material Requirement. Indeed, in 1992 and 1995 the hidden flow per capita was 15 million t, to grow in 1997 to as much as 18 million tonnes.

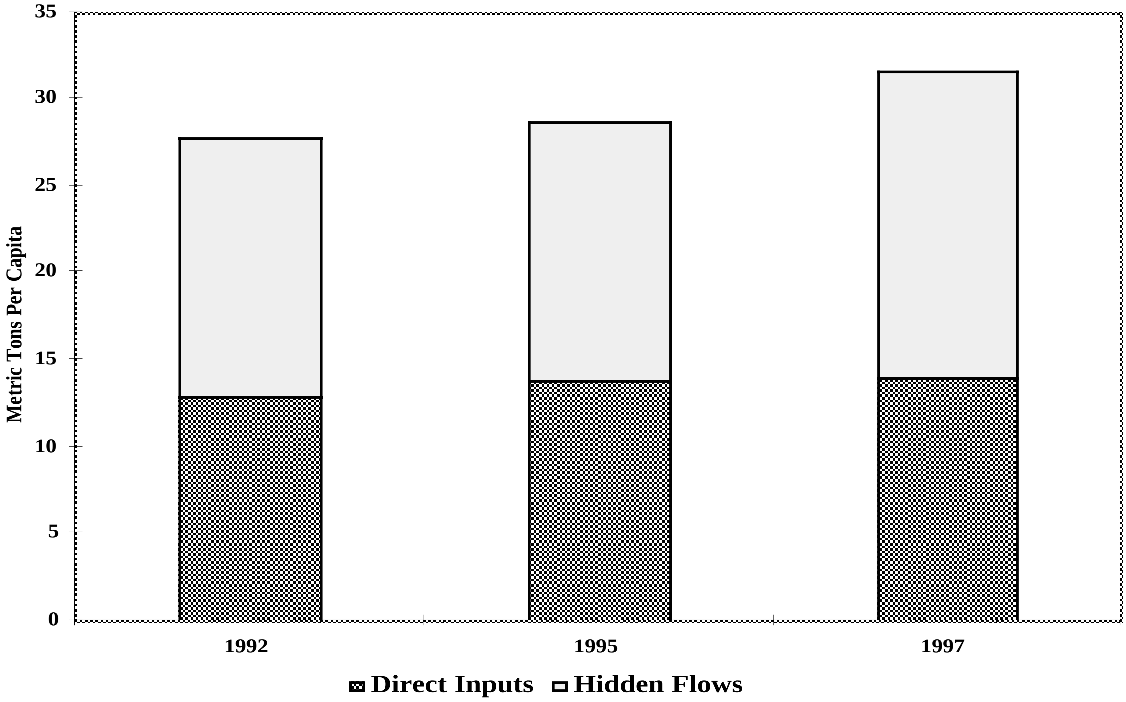

Figure 2.6: The proportions of DMI and hidden flows in TMR in Poland, 1992-1997.
Source: Sleszynski and Schütz 1999 (unpublished); InE 1999

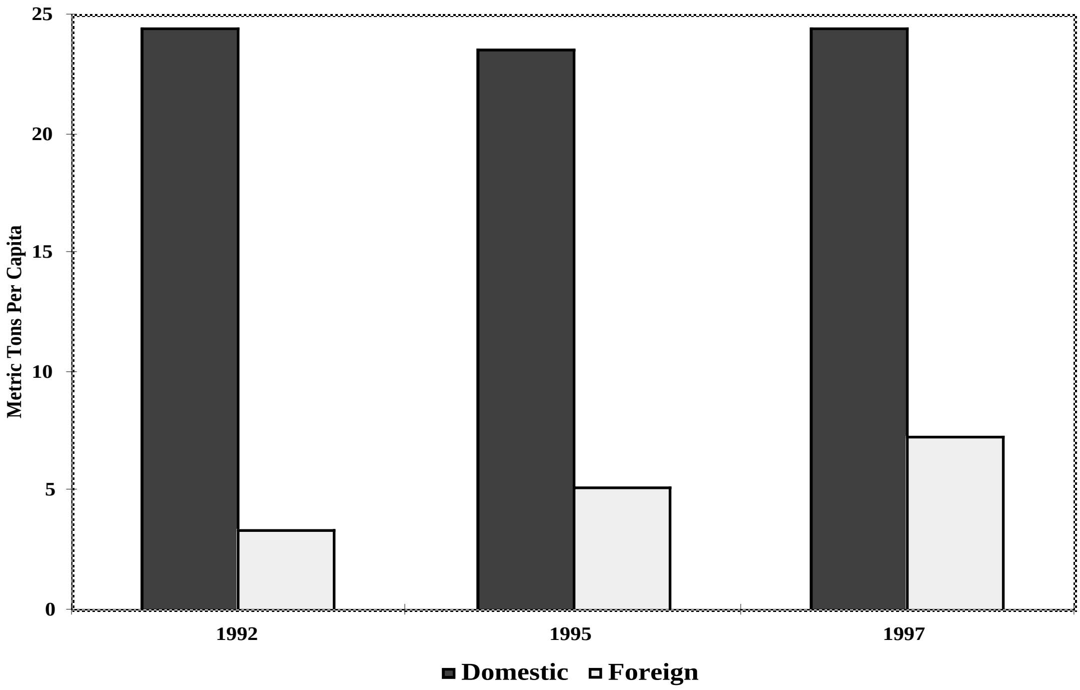

Figure 2.7: The proportions of domestic and imported material inputs in TMR in Poland, 1992-1997.
Source: Sleszynski and Schütz 1999 (unpublished); InE 1999

The examination of the structure of the direct material inputs from the point of view of their division into domestic and imported ones (figure 2.7.) shows a tendency of domestic inputs per capita to remain at a constant level of 24-25 t. Imports, which played a lesser role than domestic inputs throughout the period, increased their proportion from 12% to 21% in TMR per capita.

Throughout the period under study, energy carriers kept their leading share in the structure of TMR (figure 2.5). In TMR per capita, all the time, energy carriers kept their share of 12-13 t. The shares of other categories were similarly stable, with the exception of metals and minerals; these had a decisive effect on an increase in TMR per capita, by growing from 3 tons in 1992, to 5 tons in 1995, and then to 6 tons in 1997.

In conclusion, it should be stated again that analysis of the Polish economy by using the TMR indicator and the related measures of material input intensity confirms the thesis of significant and positive changes in the efficiency of using inputs abstracted from the environment. The rapid growth of inputs in some categories (e.g., minerals) may cause concern. The reason for a distinct increase in imported inputs is not so clear; possibly, it is an indirect result of the difficulties in balancing exports with the more rapidly growing imports, to be seen in recent years in Poland’s international trade.

Attention is drawn by the increasing proportion of hidden flows in the size of TMR. On the one hand, this increase can be explained by the growing efficiency of using direct inputs which must be reflected in the percentage growth of hidden flows. On the other hand, however, it cannot be excluded that this increase may result from insufficient actions to reduce hidden flows in the course of natural resource abstraction.

Given the results obtained so far, one may think optimistically about the continuation of the project. TMR calculations for the whole of the economy can be extended to regional surveys. An example of this can the German survey on the Ruhr Basin as compared with Northern Westphalia and the remainder of Germany (Bringezu, Schütz 1996a; Bringezu, Schütz 1996b). It seems, however, that regional comparisons, e.g., of Ruhrgebiet and Silesia, are much more difficult than those on the level of national economies.

The calculation of hidden flows for a region involves too high formal requirements related to statistical information. In the briefest terms, a region should be treated as a relatively isolated area and all material inputs should be identified as domestic versus external (analogously to the determination of domestic versus imported inputs). It turns out that it is more difficult to do so than to examine a national economy as a whole.

The basic obstacle is the availability of data which should describe a given region in very great detail. As an example, an input coming from the adjacent province should be treated in the same way as an import in the calculations of the national TMR. In addition, following the administrative reforms in this country, provincial statistics become more complicated. Therefore, efforts should concentrate, instead, on improving the TMR indicator for the national economy, with, at most, sectoral comparisons added, on the basis of statistical data collected on energy carriers, metals, minerals, building materials, agriculture and forestry.

Bearing in mind the current and future needs for information as well as the possible continuation of the project, it should be suggested that the construction of a complete PIOT table would be a relatively easy and natural follow-up to TMR calculations. In addition to data required in the study on TMR, it would then be necessary to consider the status of accumulated material mass, recycling and the material size of exports.

2.4 Strategies and Instruments for Dematerializaton

Strategies for Dematerialization

Strategies for dematerialization mean that resources are used in a more efficient way. Different strategies should focus on each stage of product life cycle: from raw matrial extraction to waste treatment (Welfens 1993b).

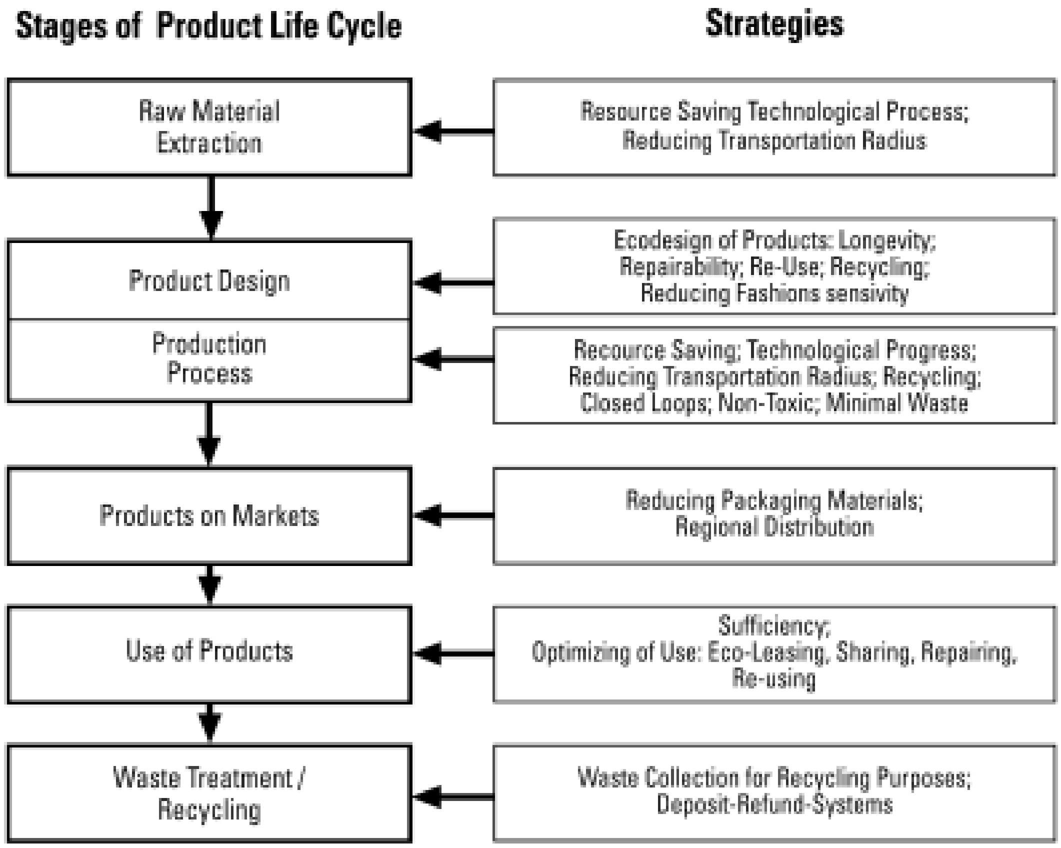

Figure 2.8: Strategies for Dematerialization
Source: M.J. Welfens, Wuppertal Institute – UM-546-1e/95

Instruments for Dematerialization

The traditional instruments of environmental policy, in particulary the use of regulations (dominant in Germany), are mostly inadequate for sustainable economic development. They induce unnecessarily high costs. A new more efficiently environmental policy is required. Ecological fiscal reform which covers ecological tax reform and the greening of subsidies, would allow environmental objectives more efficiently.

Efficient environmental policy in transforming economies requires a new design: strong orientation towards increasing resource efficiency and increasing the role of market forces and competition as a strategy for higher cost conscionsness and a higher rate of innovation.

The dematerialization concept provides ecological guard-rails for long term economic development. In this way the individual actors as well as policy makers are provided with new tools for decision-making. Here the advantage of the dematerialization concepts will become evident when compared to more specific policies aimed ad specific environmental problems. It provides common rules for decision making understandable and relevant for *all* at the same time. Firms that pursue strategies of industrial ecology and dematerialized innovation paths will be positively affected by a materials tax or tradable material input permits.

Within these parameters there is considerable space in which both the economy and society can develop restricted mainly by the self-organisation processes of the socio-economic and ecological systems. Although the market forces play an important role, in many cases economic agents will not respond to price- and quantity solutions (as provided by eco-taxes and tradable permits), which means that in these cases such solutions are not sufficient to direct the system to guarantee sustainability. In these areas, accompanying industrial policy measures would be appropriate, which would use several, combined instruments and forces technological change and structural change of the economy. The sectors and social groups negatively affected by the structural change should be aided in adapting to new lines of work.

All instruments of the traditional environmental policy should be checked, whether they are useful for dematerialization goals; some instruments should be new designed like e.g. material input tax or material input certificates.

There are some strategic instruments with influence on all stages of product life cycle, like: voluntary agreements, ecological fiscal reform, materal-input-labelling or material input certificates. The voluntary agreements and ecological fiscal reform were realised. Material-input-labelling and material-input-certificates are in the discussion. Besides strategic instruments we have a lot of other instruments they focus on particular stages of product life cycle, like charges, longer warranty, extended producer responsibility, eco-audits a.o.

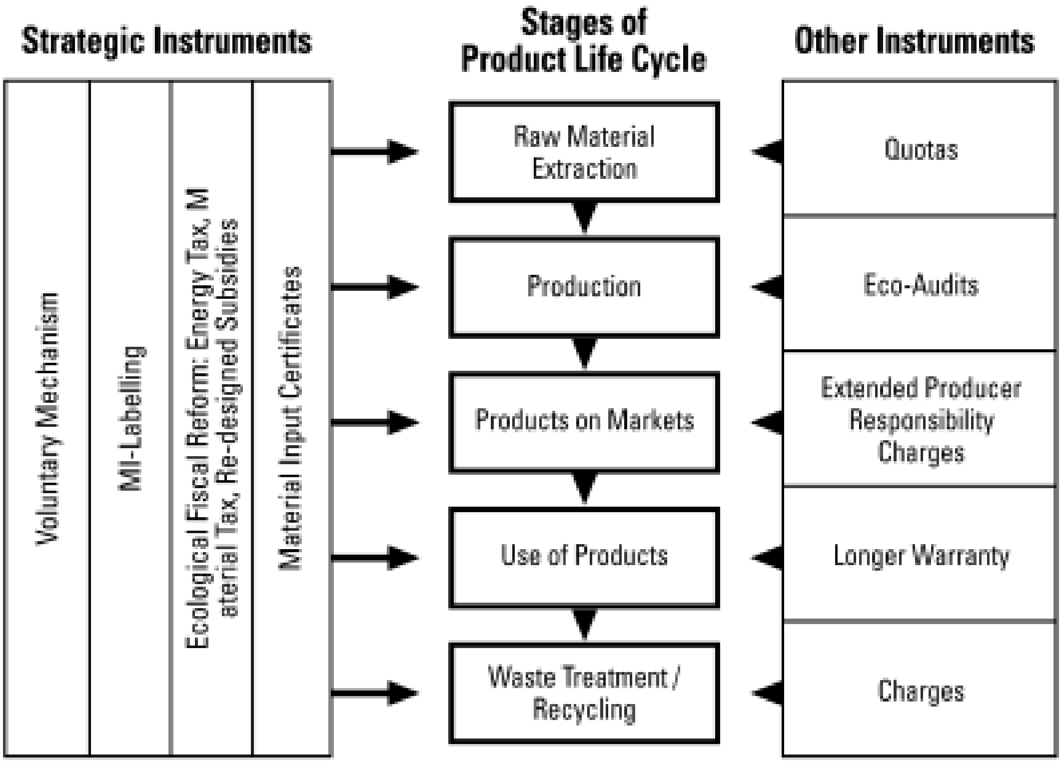

Figure 2.9: Instruments for dematerialization
Source: M.J. Welfens, Wuppertal Institute – UM-546e/95

2.5 Dematerialization instruments and environmental policy in Poland

To a slight degree, if at all, the economic instruments applied in environmental policy in Poland are designed to dematerialize production and consumption. At the present stage of transition, the system of economic instruments mainly plays a fiscal and distributive role, serving only to a lesser extent to generate incentives for economical or more rational use of resources and materials in production and consumption. The following instruments the use of which relates to the issues of dematerialization of the economy can be distinguished in Poland:

- charges for the use of the environment, including royalties paid by companies which abstract minerals and those that recover mineral raw materials from waste coming from mining or mineral enrichment processes (Art. 84 of the Act — Geological and Mining Law);
- penalties for the illegal use of the environment and its resources, including penalties for conducting an activity regulated by the Geological and Mining

Law without the required concession or in flagrant violation of its terms and conditions (the Regulation of the Council of Ministers of 24 August 1994 — Official Journal No. 92, Item 432);

- subsidies in the form of grants and preferential loans for projects in environmental protection granted from the financial assets of environmental funds, foundations and agencies which expend public and assistance funds and from bank assets (the Bank for Environmental Protection — Bank Ochrony Srodowiska S.A.);
- environmental deposits and securities designed to reduce the use of products and packaging which are very harmful or disturbing to the environment; in Poland, to a limited extent, deposits are applied for some types of standard glass and plastic containers (e. g., multiple-use glass containers for soft drinks);
- tradeable permits to emit pollutants; in Poland, they are used on an experimental basis for air pollutant emissions, with large intervention of the administration;
- tax and customs instruments; to date, in Poland, such instruments included mainly varied tax rates, applied to a limited extent (e. g., varied excise duty rates on liquid fuels), tax reliefs and preferences consisting in cut tax liabilities when a given activity or product cause less disturbance to the environment, or when a given product, piece of equipment or service are related to environmental protection (e. g., income tax exemptions for an economic activity which uses waste, or investment-related tax reliefs for companies which operate in waste collection, purchases and sorting; VAT exemptions or cut rates for some goods and services which serve directly in environmental protection).

The environmental policy instruments as applied to date in Poland do not satisfy the needs related to the implementation of the dematerialization concept in the economy, production and consumption, since

- they do not apply to all, or even most, material flows in the economy, i. e., the processes of abstraction, processing, movement, use and disposal of fuels, raw materials and semi-finished and final products;
- for the most part, they are emission charges, thus, they are not designed to prevent excessive uses of natural resources of the environment, but focus instead only on actions to reduce pollutant emissions, which are not always effective in some components of the environment;
- they do not reflect the external costs, e. g., those related to the use of the environment and its resources;
- they are not directly designed to reduce the use in production and consumption of a large number of products which disturb the environment, e. g., those used on a mass and dispersed scale, including plastic products, plastic and

cardboard packaging, fuels, detergents, paints and varnishes, fertilizers and pesticides;
- they do not induce a sufficiently strong interest on the part of producers and users of some products which are disturbing to the environment in their recovery, recycling or safe storage, e. g., lubricating oils and batteries;
- they do not create sufficient conditions and incentives for the use of cleaner technologies and environmentally friendly product-related innovations (eco-labelling is not yet applied to a sufficient degree in promoting energy and material efficient products);
- they do not encourage companies to undertake voluntary commitments to improve the environmental profiles of companies, product technics and technologies, products and services;
- they do not encourage the administration to establish a system of statistics and objective measures of the effect of economic activities on the state of the environment.

At present, the environmental policy instruments in Poland are not adapted to the challenges posed by the modern, competitive and innovative market economy. In their macro- and micro-economic dimensions, the social policy instruments do not match the practical needs for higher resource efficiency in the processes of production and consumption, either. Although in the hitherto transition period some systemic and legal solutions were established, leading to the final effect of more economical and rational use of resources in the basic sectors of the economy and consumption, they should be regarded as some progress compared with the wasteful nature of the command and allocation economy rather than as a breakthrough towards dematerialization when understood, e. g., in terms of the Factor Four strategy.

For this purpose, the system of economic and environmental policy instruments now in place in Poland should be much enhanced, in terms of both the set of instruments and their more consistent enforcement. It is indispensable to eliminate gaps in the system of identifying entities which use environmental resources and the mechanism of collecting environmental charges. Above all, a shift must take place in the strategy of influencing the economic system and the consumption sphere towards preventing the generation of pollution and the wasting of resources “at the source”. It is essential that criteria ensuring that material inputs may be reduced should be considered in the economic sphere even as early as when decisions are taken to invest, to begin production, to buy machinery, equipment, raw and other materials; and in the sphere of consumption, including mass consumption, as early as when purchases of consumer goods and service are planned. In Poland, such a system of economic and environmental instruments, or such a mechanism of incentives for producers and consumers are not yet in place, although, as mentioned above, some elements of this system are in operation, though in a yet imperfect or incomplete way.

In addition to the imperfect instruments applied in environmental and economic policies, the incomplete use of the potential of Poland’s economy in the last decade to improve the state of the environment and to bring more economical and rational use of natural resources in production and consumption was also largely brought about by drawbacks in the environment management system. They created an unfavourable conditions for the implementation and operation of these instruments. They included[4]:

- insufficient public participation,
- the lack of consistent environmental policy, macro-economic policy and sectoral policies in the implementation of the objectives of energy and material efficiency and in creating environmentally friendly attitudes in consumption,
- the failure to make use of the privatization and restructuring processes to improve the state of the environment and to achieve the effects of saving and rationalizing the use of resources in the economy, particularly in the industries which are traditionally disturbing to the environment (mining, metallurgy, energy, chemical industry) and in agriculture,
- the giving of priority to “end of pipe” actions and investment projects, bringing the effect of a contingent improvement rather than a long-term environmental impact which is the essence of sustainable development,
- the hardly flexible system of environmental standards and charges,
- the slight range and inconsistent application of market-based environmental instruments,
- the unclear criteria of selection of investment projects,
- the failure to apply the external costs as a criterion for selecting the investment directions,
- the failure to adapt investment effectiveness evaluation indicators to the specific nature of environmental projects.

It should be borne in mind that in such conditions, unfavourable for economical and rational use of natural resources, the operation of environmental and economic policy instruments cannot be fully effective.

An essential factor which induces pro-saving behaviour of producers and consumers is the mechanism for funding projects in the sphere in question. It should be admitted that over the last decade no effective mechanism was developed in Poland to support pro-saving projects in production and consumption. The mechanism of environmental funds and external finance sources was applied to finance environmental actions and investment projects which, in an overwhelming proportion, addressed “the end of the pipe”. The data

[4] See Wojciech Stodulski: "10 Years of Transition in Poland — Environmental Protection. Diagnosis of the State of the Environment and the Implementation of the Environmental Policy of the State", Institute for Sustainable Development. Report 1/1999, pp. 26-40.

of the Main Statistical Office indicate that almost 3/4 of the financial assets of environmental funds are allocated exactly to such investment projects every year, and only 1/4 to preventive and integrated projects[5] which bring long-term environmental impact, in keeping with the principles of sustainable development.

The priorities of environmental funds[6] and government agencies which administer foreign assistance funds include practically no projects designed to save and rationalize the use of natural resources[7]. Other departments of the government show only slight activity in this field. Economic entities in Poland are left to cope on their own in the sphere of improving resource productivity which is so important for sustainable development. This should be changed without waiting for the positive effects of the market. In the market economy, competitiveness is achieved due to competition between economic entities and long-term actions undertaken by government agencies in support of innovations in technological processes and products. Such a mechanism of joint action for dematerialization of production and consumption is still absent. Its establishment should be a priority objective of the new Environmental Policy of the State in the coming years.

2.6 Recommendations for an Input-Oriented Environmental Policy in Poland and in EEC countries

Systemic transition in Poland has brought a new economic system and the need to define a new market oriented environmental strategy. Polish environmental programs are strongly oriented towards pollution control.

Most of the environmental objectives concern the output side of the production process. The current environmental policy focus is on pollution control, often with end-of-pipe technologies. The instrumental solutions of environmental policy in CEE are similar to OECD countries (OECD 1994, pp. 36-56; REC 1994b).

The starting point for a new input oriented environmental policy is a broader understanding of the term pro-environmental or ecological. It means not only non toxic, low polluting but also low-material intensive or energy efficient. The question, what pro-environmental efficient investment is, should be adressed. In

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5 See also Marian Grzesiak, "Danger in numbers", Ekoprofit No. 12/1998.

6 The priority projects in 1999 interdisciplinary programmes of the National Fund for Environmental Protection and Water Management include two projects which can be regarded as ones in the scope of dematerialization:
• support to the implementation of Cleaner Production and
• saving raw materials.

7 It is difficult for one to be convinced by the argument that the effects from such projects are market-based and, therefore, need no support with public funds, particularly so as, at the same time, support is given to infrastructure projects, e. g., in water supply and purification and waste water collection, with the argument that this field does not bring profit.

conventional term it means filter, scrubbers, diffusers etc. Dematerialization would mean investment for low-material and low-energy production, processes and products. Research about material intensity of products and processes should be promoted.

Broad information to the consumers about material intensity of consumer goods should be given. The economic analysis should consider the effects of the full life cycle of materials and energy. This way of long term thinking should be incorporated in the process of resource planning. Longevity of products should be increased.

- The regulation should focus on resource intensive industries and intermediate products.
- Reshaping the economy to conform to market principles is intended to pressure greater economic efficiency, which may also lead indirectly to increasing resource productivity. Firms under pressure to minimize costs will be forced to reduce their raw material and energy inputs and will also be given incentives to innovate. This, however, will be realized only if soft budget constraints of firms are not continued; i.e. soft loans by state banks and generous subsidies have to be abolished. From the perspective of dematerialization approach it is adequate to privatize resource intensive and energy intensive industries first.
- Dematerialization requires a re-examination (re-design) of processes, products, technologies and materials. A system of incentives for efficient use of resources and energy should be designed. One legacy from socialist economy that appears to be continued in some countries, is artificially low prices for primary resources compared to prices of final products. Gradual price liberalization has not changed much the relationship between prices of primary resources and final products.
- Dematerialization and foreign investment: Among the investors interested in CEE short-term business perspective has dominated. Their business plans were attracted by opportunities for hardly marketable products and technologies for environmental reasons. In the future one should have regulations concerning material intensity and energy intensity for major industries such that also foreign investors will contribute to a green modernization of Poland’s industry.
- Eco-labelling could become an important element of consumer information and competition.

All post-socialist countries could benefit much from a comprehensive environmental policy approach. Given the resistance of industry and the tendency to simply imitate EU policies, the adoption of a dematerialization approach represents an enormous challenge. Prospective EU countries have a rather strong incentive to adopt innovative policy strategies.

Conclusions and recommendations

All the issues presented in this report should be recognized as hardly known and popular among politicians, representatives of the administration, business, science, environmental non-governmental organizations and those who are interested in improving the macro- and micro efficiency in Poland. In contrast, radical actions are needed to reduce the present technological gap between Poland and highly developed countries, in order to make up for the development backlog, to be seen, e. g., in the twice or three times as large consumption of natural resources per unit of the Gross Domestic Product in Poland compared with those countries.

The Research Programme “ECOPOL — Ecological economic policy — strategy for Poland in the 21st century” and the publication of this Report are projects which at least partly respond to challenges of key significance for improving the management of natural resources in Poland in keeping with the principles of sustainable development. The environmental effect of the Research Programme ECOPOL is related directly to the implementation in Poland of the methodology for estimation and analysis of the total material requirement of the economy, along with the resultant recommendations concerning the principles and instruments of economic and environmental policies which would ensure the reduced intensity of the consumption of raw and other materials throughout the country. It should be stressed, however, that the achievement of the environmental effect depends on the initiation of a social and economic process whereby the institutions of the national Government and local governments as well as economic entities and households would assimilate, understand and adapt the principles of dematerialization, as a result of which, decisions taken would comply with these principles. The dissemination actions should be supported by specific institutional and legal solutions contained in the Environmental Policy of the State, in sectoral policies, and, in particular, in the financial and taxation policies of the State. Such a consistent policy designed to support dematerialization processes is still absent in Poland.

The question arises: what next? What should be done in the scope of developing the concept and practical aspects of dematerialization in order to achieve tangible benefits for the Polish economy in the coming years? On the basis of the experiences gained in the course of the implementation of the Research Programme ECOPOL and the reading of the Report, a variety of conclusions can be drawn with the nature of guidance and recommendations for environmental and economic policies. As far as “the greening” of sectoral policies is concerned, in-depth studies should be carried out on the factors which affect material-intensity in these sectors. Detailed legal and institutional solutions and the projected policy instruments in the sectors result from the specific technical, technological, economic and organizational conditions. The identification of these factors and conditions with a view to reducing material intensity and waste generation is now poor in Poland. To date, no such in-depth analyses have been performed; it should be done in an approach encompassing the whole economy and for individual sectors as well.

The other priority tasks of key importance for the strengthening of dematerialization processes in Poland and for coping with economic and technical competition from the EU15 countries are as follows:

in the scope of strategy

- to reorient environmental policy from priorities with the nature of "end-of-pipe" solutions to the reduction of potential sources of environmental burdens,
- to apply to a greater extent market-based environmental instruments in addition to the now dominating regulations with the nature of orders and inspection,
- to review environmental policy strategies and instruments from the point of view of their usefulness for dematerializing the economy and consumption,
- to prepare, discuss thoroughly with the public and then implement an environmentally friendly fiscal reform, designed to diminish the total material requirement and reduce waste generation and emissions,
- to promote innovations in the scope of environmental efficiency, including new technological solutions, new services, joint use of products and services,
- to develop environmental education.

in the scope of specific solutions

- to consider the economic and financial effects of different scenarios of the implementation of the environmentally friendly fiscal reform,
- to analyze the subsidies applied in Poland from the point of view of their effects on the environment,
- to analyze and consider the possibilities of using subsidies in promoting new technologies (co-financing Cleaner Production programmes),
- to analyze and consider the possibility of promoting environmental management mechanisms in the companies in the sectors with adverse impacts on the environment, particularly energy and material intensive sectors,
- to enhance the transparency of subsidies granted from public funds in the fields and sectors which are important for the environmental quality and the level of the total material requirement in Poland,

- to consider the possibilities and define the effects of the active promotion of the sector of Small and Medium Enterprises (SME) from the point of view of the development of the environmental market in Poland, particularly in respect of reduction of the energy and material intensity of services and products, minimization of waste and enhancement of environmentally beneficial features (the environmental efficiency of services and products),
- to develop the mechanism for informing the public regarding subsidies granted from public funds in fields and sectors which are important for the environmental quality and the level of the total material requirement in Poland,
- to develop a mechanism for informing the public regarding the material intensity of products (eco-labelling according to the criterion of the consumption of material resources per unit service or per product),
- to prepare the implementation concept for tradeable permits to emit pollutants in regions which are sensitive from the environmental point of view,
- to launch a research programme to evaluate the effects of the Environmental Tax Reform in the context of reducing tax burdens on entrepreneurs while, at the same time, increasing the taxes on resources used,
- to implement a research programme on the possibilities and effects of the implementation of tradeable permits on the consumption of material resources in Poland,
- to continue the calculations of the Total Material Requirement indicator for the Polish economy and make their results accessible to the public.

It can be seen that the list of projects in support of the dematerialization processes in Poland is quite long, although it does not include all the specific subjects, particularly in respect of sectoral actions. The launching of at least part of them now would confirm the positive approach of the administration to the dematerialization issue by recognizing it as a priority direction of the Environmental Policy of the State and the economic policy in the coming years. Dematerialization leads to a change in production and consumption patterns; thus, it is a long-term process of social, economic, legal and institutional nature. The effects of this process in the form of lower energy and material intensity in the economy will be of key significance for the future position of Poland in the European Union.

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Annex 1

Methodology of calculation of the TMR for Poland

In starting to collect statistical data required for the calculation of the TMR indicator and the related measures of material input intensity for the Polish economy, the information scheme given in Annex 2 was applied. It is a modified version of the approach followed in the publication “Resource Flows” (Adriaanse et al. 1997). The proposed scheme was applied to develop tables in the EXCEL programme. Then the tables were applied as data were collected and ordered (see Annex 2). The basic change with respect to the tables published for other countries was the greater specification as to which data were recorded as direct inputs and which, derived by using relevant recalculation factors or additional data, were the aforementioned hidden flows which accompany the abstraction of material inputs.

Initially, the intention was to examine a long time series, but given time and financial limitations the field of analysis had to be narrowed. It was decided to focus on three years: 1992, 1995 and 1997. Originally, it was intended to examine 1991 as the last year of economic depression. It turned out, however, that the availability of data for that year was seriously limited and, in addition, some categories were classified in a different way than in the other years, mainly for imports, preventing comparison with the recent years. 1995 and 1997 were chosen in order to identify the current trends in the general economic and environmental intensities of material inputs in the national economy.

It should be pointed out that all the inputs under study are expressed in weight units. This made it necessary to collect data on material inputs in tons or to find appropriate recalculation factors where the official statistics did not give the weight of domestic or imported inputs. In the TMR methodology, it is assumed that the weight of inputs for a given country includes domestic abstraction and imports. For domestic inputs this means that the abstracted quantity of a resource, e.g., brown coal, expressed by weight, will be covered by TMR calculations, irrespective of whether this coal will be burned, used in the pharmaceutical industry or simply exported.

The English term *hidden flows* means those material inputs/flows that emerge indirectly as it were as a result of man's acquisition of inputs, later to be applied directly. In consequence, TMR would be the indicator of the total material requirement for a given economy, with consideration given to both direct inputs and the related hidden flows.

In the case of non-renewable raw materials, the hidden flow is the part of abstracted matter of no commercial value (the non-saleable production, including overburden gangue) and the disturbance of the material base, expressed in weight, caused by excavation for infrastructure. In the case of domestic and imported non-renewable raw materials, the hidden flow calculations in Wuppertal were limited exclusively to the soil erosion caused by agriculture — the reason for this simplification was the lack of sufficiently exact data on other forms in which hidden flows occurred.

The example below explains how the hidden flow is determined. Let us assume that the acquisition of one ton of a certain (non-renewable) raw material involves the necessity of abstracting 20 tons of overburden. In addition, the abstraction process itself requires, e.g., the disturbance of the land surface (excavation) calculated to represent 30 tons by weight. As a result, the hidden flow for one ton of the acquired raw material amounts to 50 tons (the unit hidden flow) in this example. When 1000 tons of the exemplary raw material are abstracted every year, the total material requirement (TMR) for this raw material is 51,000 tons (1000 + 1000x20 + 1000x30).

A difficult methodological problem is how to determine the hidden flow coefficients for domestic inputs and foreign inputs (imports), and then to apply these indicators correctly in further calculations. For many years Dr. Schütz from the Wuppertal Institute collected information and statistical data, on the basis of which he was able to develop his "personal data base", also, or rather first of all, containing hidden flow coefficients. This means that knowing the type of input and its origin (the place of abstraction in Germany or the country from which the raw material or semi-finished product was imported), it is possible to calculate directly the burden by weight which the acquisition of a given quantity of a given material caused.

In the Polish conditions, quite a large number of useful data or coefficients could be collected for domestic inputs, on the basis of experts' knowledge or from analysis of sectoral statistics. As an example, in the calculation of the hidden flow for brown coal, it is, firstly, necessary to know the annual material quantity abstracted at brown coal mines and detract from this quantity the production of brown coal which is subsequently sold (or to use the information on the commercial value of brown coal in the abstracted raw material); secondly, we need to know the size of the open-pit mine in order to give the material quantity of the land surface disturbed for the purpose of brown coal mining. It should be noted that data concerning individual mines are applied in the German calculations, however, it is possible to conceive of a permissible simplification consisting in the determination of hidden flows for certain geographical areas, groups of mines or, ultimately, in estimating the hidden flow for the whole of the domestic brown coal mining.

It turned out, in practice, that because of time limitations it was necessary to adopt essential simplifications. Although the extent of the total mineral resource abstraction was known, it was not always possible to determine which part of the abstracted material in a given year had a commercial value and could be considered a direct input. As a result, it was necessary to apply approximate estimates which represented the relations between the commercial and non-commercial components of the abstracted matter for quantities of specific minerals mined from given deposits. This means that it is necessary to apply standard coefficients, i.e., hardly precise measures of the proportion of hidden flows in the total abstraction.

In all the cases where desirable information on indirect inputs related to abstracted material inputs was found to be missing, to a wide extent, the “bank of coefficients” in Wuppertal was drawn upon. In the case of most figures used, it proved possible to verify that the German coefficients roughly corresponded to the Polish conditions of input acquisition.

The case of imports was much simpler. The calculation of hidden flows for imports by using the “German” coefficients does not pose any methodological problem. In the Polish study, data were available on the structure of imports, including the size of the imports and the countries of their origin, allowing the hidden flows to be calculated for imported raw materials, semi-finished and final products. In keeping with the TMR methodology, it is the importer who is liable for the hidden flow caused by imports. The size of a hidden flow depends on the quantity and origin of the imported material input, whereas the hidden flow coefficients to be calculated — provided that they are known — are universal no matter which country makes such imports.

Because of methodological difficulties — the absence of unambiguous and reliable recalculation factors — in the international studies undertaken to date only selected hidden flows were considered for imported final products. This is a serious inconsistency; it is, however, warranted by the insufficient knowledge of the complex impact of products generated on the environment.

In the course of the implementation of the project, the greatest difficulty proved to be the incompatibility between the classification systems in place. The Main Statistical Office, the key partner to provide statistical data, uses the PCB classification, whereas the German classification applied to date in TMR studies tended to result from a pragmatic approach to available and useful data from German statistical sources. As a result, a mode of operation had to be found to enable one to apply the German hidden flow coefficients. All the categories of inputs, primary those of imported inputs, for which hidden flow coefficients were available, were ultimately identified in the Polish statistics. In some cases, there was complete correspondence between categories, while some other categories adopted under the PCN system had to be aggregated or disaggregated. The calculations of the sum total of imported inputs were limited to four-digit symbols of PCB classification, whereas the identification of some imported categories according to their country of origin required going down to the level of six-digit, or even eight-digit, symbols in PCB classification.

It is self-evident that, unless it becomes necessary to do so, it is not well-advised to aggregate individual types of inputs in the categories distinguished. Each aggregation involves the use of increasingly less matched, i.e., increasingly imperfect, hidden flow coefficients. As a result of averaging already averaged quantities, the results for successive years will not represent the actual changes taking place within the economy, failing to show significant shifts in the use of natural resources, and, accordingly, changes in the size of hidden flows.

It should be stressed that a uniform and universal input classification is an essential condition for correct and simple comparison of TMR estimates for a large number of different countries. It would be well-advised for future TMR calculations, and, accordingly, the structure of “the bank of hidden flow coefficients”, to apply the commonly adopted international classification. It should be noted here that the Regulation of the European Commission of the European Communities of 31 December 1998 (Commission Regulation EC No. 1232/98), with a two-year adjustment period, introduced the Classification of Products by Activity — CPA. After it has been adopted by the Member States, this classification should provide a basis for analyses, comparisons and calculations related to TMR.

In the original version, the material inputs covered by TMR calculations did not include water and air. It is consistent not so much with the idea of the TMR concept (after all, water and air components are also material inputs) as it corresponds to some agreement adopted some time ago by the research teams from the four countries: Germany, the USA, the Netherlands and Japan. In technical terms, the exclusion of water and air from TMR calculations also results from the fact that in terms of weight these inputs would dominate all the other inputs, preventing legibility of the changes taking place “within” the total material requirement.

Since the TMR indicator is covered by an unregistered copyright, in introducing modifications, TMR and “expanded” TMR should be considered separately. As for studies themselves, it is highly recommended that calculations and international comparisons of TMRs should be followed by the determination of the total material requirements, including water and at least oxygen bound as a result of pollutant emissions as material inputs contributing to changes caused in the environment.

Annex 2

Table 1: Total material requirement and individual categories of material inputs in the Polish economy in 1992 — 1997 (in tons)

		1992	1995	1997
DOMESTIC				
Energy carriers	Commodity	201699997	204729167	205004636
	Rucksack	261506096	236031316	236154237
Metals	Commodity	27283400	29978445	29482507
	Rucksack	1852700	1798155	1380643
Minerals	Commodity	118685073	132796634	133447349
	Rucksack	27850571	25760434	40871683
Soil excavation		93990414	63715358	91673778
Agriculture		83340484	90612500	87064532
Forestry		22037000	22492000	23497000
Fishery		493723	442170	372674
Hunting		16400	12305	10550
Erosion		99444667	101432958	96841287
FOREIGN				
Energy Raw	Commodity	16099164	19594764	23230404
	Rucksack	3247580	7373087	15587497
Energy Semis	Commodity	2541277	3039019	4811971
	Rucksack	694394	951829	1485354
Metals Raw	Commodity	8539006	11324155	10958566
	Rucksack	16588467	27315301	24545656
Metals Semis	Commodity	242350	726312	712220
	Rucksack	19760411	20994434	28424834
Metals Final	Commodity	1209407	1930476	3439057
	Rucksack	11022740	15339766	29568548
Minerals Raw	Commodity	1492579	2196098	2486842
	Rucksack	8524452	30872020	76466750
Minerals Semis	Commodity	468227	1213972	1686138
	Rucksack	1772950	6107188	7212114
Minerals Final	Commodity	613639	1135272	1996470
	Rucksack	2776311	15717465	5834355
Agricultural biomass Raw	Commodity	1520809	2045812	2059684
	Rucksack	8848874	9315638	10927303
Agricultural Products	Commodity	2713936	3760477	3796572
	Rucksack	15386176	13701546	17784341
Forestry Raw	Commodity	33348	346045	304357
Forestry Semis	Commodity	92194	194748	269739
Forestry Final	Commodity	460505	1003709	1725894
Fishing, Hunting	Commodity	162725	183199	229314
Other Import	Commodity	2428713	3228031	4677935
DMI		**492173956**	**532985311**	**541264410**
TMR		**1065440758**	**1109411806**	**1226022789**
Population in 1000		38418	38609	38660
DMI in tons per Capita		**12,8**	**13,8**	**14,0**
TMR in tons per Capita		**27,7**	**28,7**	**31,7**
GDP in Mio. US$		84326	126348	143066
DMI/GDP (kg per US$)		**5,83**	**4,22**	**3,78**
TMR/GDP (kg per US$)		**12,63**	**8,78**	**8,57**
GDP/DMI (US$ per t)		**171**	**237**	**264**
GDP/TMR (US$ per t)		**79**	**114**	**117**
Total Import	Commodity	38617879	51922089	62385163
	Rucksack	88622354	147688274	217836750
Total Water in Mio. m3		12570	12066	11799
Total O2 for Emissions in t		349950000	333496000	376722000
Water in m3 per Capita		327	313	305
O2 in tons per Capita		9	9	10

Source**:** Sleszynski and Schütz 1999 (unpublished); Ine 1999

Table 2: Material inputs per capita in the Polish economy in 1992 — 1997 (in tons per capita)

		1992	1995	1997
DOMESTIC				
Energy carriers	Commodity	5,25	5,30	5,30
	Rucksack	6,81	6,11	6,11
Metals	Commodity	0,71	0,78	0,76
	Rucksack	0,05	0,05	0,04
Minerals	Commodity	3,09	3,44	3,45
	Rucksack	0,72	0,67	1,06
Soil excavation		2,45	1,65	2,37
Agriculture		2,17	2,35	2,25
Forestry		0,57	0,58	0,61
Fishery		0,01	0,01	0,01
Hunting		0,00	0,00	0,00
Erosion		2,59	2,63	2,50
FOREIGN				
Energy Raw	Commodity	0,42	0,51	0,60
	Rucksack	0,08	0,19	0,40
Energy Semis	Commodity	0,07	0,08	0,12
	Rucksack	0,02	0,02	0,04
Metals Raw	Commodity	0,22	0,29	0,28
	Rucksack	0,43	0,71	0,63
Metals Semis	Commodity	0,01	0,02	0,02
	Rucksack	0,51	0,54	0,74
Metals Final	Commodity	0,03	0,05	0,09
	Rucksack	0,29	0,40	0,76
Minerals Raw	Commodity	0,04	0,06	0,06
	Rucksack	0,22	0,80	1,98
Minerals Semis	Commodity	0,01	0,03	0,04
	Rucksack	0,05	0,16	0,19
Minerals Final	Commodity	0,02	0,03	0,05
	Rucksack	0,07	0,41	0,15
Agricultural biomass Raw	Commodity	0,04	0,05	0,05
	Rucksack	0,23	0,24	0,28
Agricultural Products	Commodity	0,07	0,10	0,10
	Rucksack	0,40	0,35	0,46
Forestry Raw	Commodity	0,00	0,01	0,01
	Rucksack	0,00	0,00	0,00
Forestry Semis	Commodity	0,00	0,01	0,01
Forestry Final	Commodity	0,01	0,03	0,04
Fishing, Hunting	Commodity	0,00	0,00	0,01
Other Import	Commodity	0,06	0,08	0,12
DMI		**13**	**14**	**14**
TMR		**28**	**29**	**32**
Total Import	Commodity	1,01	1,34	1,61
	Rucksack	2,31	3,83	5,63

Source**:** Sleszynski and Schütz 1999 (unpublished); Ine 1999